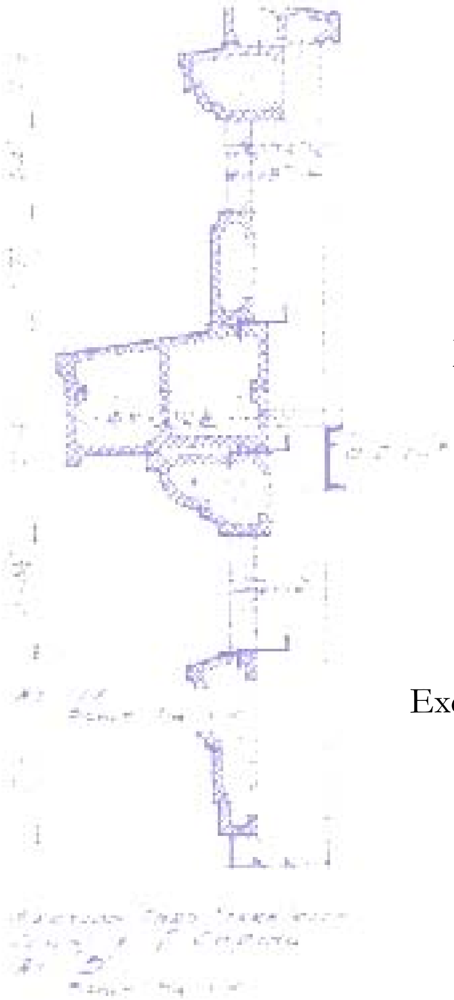
Orpheum Theatre
Terra Cotta/Masonry Restoration



Hennepin Avenue
Minneapolis, Minnesota

Owner:
Minneapolis Community Development Agency

MCDA Contract No. CD-02.13

Building Management Report
Executive Summary, Current Investigation Observations,

Evaluation and Maintenance Strategies

Phase One Restoration

HGA.

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Building Management Report for the Orpheum Theatre

Orpheum Theatre Terra Cotta/Masonry Restoration Report

I. Executive Summary

Project Description

The scope of work we were asked to perform includes investigation, repair and replacement of the existing original terra cotta units and face brick masonry as necessary to stabilize the Orpheum Theatre. We began investigating the condition of the terra cotta and face brick masonry in early February 2002 with follow up investigations in March and in early April. Due to limited accessibility to all terra cotta work, and the fact that snow was covering portions of the terra cotta at each visit, we proceeded to photo document the conditions that we observed with each visit providing more information than the last. Documentation of existing conditions discovered during these investigations can be found in the *Orpheum Theatre Terra Cotta/Masonry Restoration Project Manual* (April 10, 2002).

Past documentation indicates that all terra cotta units were cleaned in 1992 and that repairs were made at the Hennepin Avenue elevation at that time. For the current investigation, the Hennepin Avenue and 10th Street elevations were briefly reviewed. Although it is not expected that work be performed in these areas during this phase, documentation of existing conditions was included in the project manual. Our conclusion was that previous repairs appear to be in generally good condition and that only a few spalled units are candidates for future repair. The 1992 stage house addition is in reasonably good condition, after nearly ten years, although there are several open joints along the horizontal terra cotta dripstone band where we would recommend selective repointing.

To our knowledge, terra cotta along the 9th Street and Hawthorne Avenue elevations is original and has not been previously repaired. Joints between terra cotta units in these areas are also probably original and had not been well maintained. Long-term water damage prior to roof repairs made in 1992 has compromised brick masonry along parapets and at roof connections and has had a continued effect on nearby terra cotta. As would be expected, conditions at these locations are seriously degraded.

As we began our investigation, it became obvious to us that many terra cotta units were in an advanced state of deterioration and that methods for repair/replacement were likely to be much more complex than was first thought. As the overall condition of the building was revealed, we came to realize that the allocated budget was not adequate to cover the full range of extensive repairs required to stabilize the exterior. With that in mind, we assigned each repair a priority status and presented the project as part of an ongoing process in which implementation of the various repairs could be accomplished in phases over an extended period of time. The first phase, our current work, concentrates on areas or conditions perceived to be a potential life safety hazard. Other high priority conditions include architectural or structural issues that require immediate attention to prevent further damage that could easily become a life safety issue in the near future. Moderate priority, low priority, and cosmetic issues were documented as a matter of record.

With the scope narrowed to include only high priority repairs, the main thrust of the investigation concentrated on the 9th Street elevation and the corner at 9th Street and Hawthorne Avenue. The first level of investigation was confined to observation and documentation of the existing surface conditions of the terra cotta units and associated brick masonry immediately adjacent to these areas. This investigation, although comprehensive, was considered preliminary due to limited access to many terra cotta units and to the general inaccessibility of encased steel anchorage systems. Information from this level of investigation was incorporated into the bid documents and Project Manual. The second level of investigation, conducted by the general contractor in association with the architect and structural engineer, is ongoing and will concentrate on determining the condition of the anchorage and structural steel backup systems supporting suspect terra cotta elements. Results from an early round of investigation are included in this report. Supplements to the report will be added as unknown conditions are explored and assessed.

PRELIMINARY INVESTIGATION

Findings

Our preliminary observations concluded that there were several specific areas (tower cornices, 9th Street balcony, 9th Street cornice, Hawthorne Avenue lintel) where terra cotta pieces consistently showed signs of severe damage. Long-term water damage, prior to roof repairs made in 1992, has compromised brick masonry at parapets and roof connections and has had a continued effect on nearby terra cotta. There appears to be a direct correlation between damaged brick masonry and concentrated areas of severely damaged terra cotta. Areas showing signs of severe deterioration were flagged for a second round of investigation to include structural analysis of steel support systems.

Continued water penetration is the ultimate source of most material degradation. Generally, we believe most of the damage to terra cotta and associated steel is due to poorly maintained joints at the terra cotta units. As these joints begin to fail, water infiltrates into the inner cavities of the units and eventually results in: corrosion of interior steel support elements and anchors; damage to surrounding masonry associated with increased stresses from rusted steel; advanced deterioration of terra cotta due to repeated freeze-thaw cycles; failure of terra cotta units. Repointing open and damaged joints will prevent additional moisture from entering the system, thus reducing one potential source of further damage, and will extend the life of the remaining terra cotta units. We have assumed one hundred percent repointing of terra cotta units on both the 9th Street and Hawthorne Avenue elevations and have indicated specific areas of brick masonry for selective repointing.

Although mechanical damage to terra cotta is most often attributed to backup steel corrosion, at the pedestrian level it can also be attributed to sidewalk or adjacent building movement, deicing chemicals, snow removal, vandalism, or other related conditions. Ideally, all damaged units would be carefully removed and repairs made to both the terra cotta and associated steel. This is not always economically or technically feasible and in many cases is not recommended due to the threat of additional damage to surrounding units.

Our goal for this phase is to repair as much terra cotta and steel as possible within the given budget. To accomplish this, we adopted a conservative approach that strives to complete as many of these repairs in place as is reasonably practical. Repair is more consistent with the Secretary of the Interiors Standards for restoration of historic buildings and is also more cost effective than replacement. Our strategy simultaneously protects both budget and historic materials. Moderately damaged or miss aligned terra cotta units were therefore considered to be strong candidates for repair in place as long as the backup steel support system retained its structural integrity. Replacement pieces will be ordered when necessary.

IN-DEPTH INVESTIGATION

Findings

Our engineers are concerned that the supporting steel may be severely compromised at areas where terra cotta damage is evident. In many locations, severely corroded steel support members are visible where joints have opened up or are missing. As the investigation process continues, deteriorated steel members have indeed been uncovered. In some cases the steel member, although corroded on the surface, still retains its intended structural capacity. There are other situations however where steel will need to be reinforced or potentially replaced. Decisions, based on structural analysis of each individual member, will have to be made on a case by case basis.

As noted in the report, the structural engineer has concerns as to the structural integrity of the steel supporting structure at the 9th Street balcony, the 9th Street cornice, and the lintel on Hawthorne Avenue. Sagging terra cotta band and soffit units that clad the Hawthorne Avenue lintel have been supported on wood timbers since the1992 renovation work. Deteriorated steel is visible at a number of locations including the inside face of the building corresponding directly to the steel supporting the large projecting cornices high above the street. The current investigation has also led us to question the structural integrity of perimeter roof support beams at the two towers. The condition at south tower is documented in this report and we anticipate uncovering similar conditions at the north tower. These areas remain the focus of our ongoing investigation and will, because of potential life safety hazards, determine the direction and extent of repairs we accomplish in phase one.

Deteriorated steel should be replaced with galvanized or stainless steel where possible. For those situations where replacement is not practical at this time, accessible surfaces of corroded steel will be ground smooth and painted with high performance coatings. It must be understood that the corrosion process will most likely continue in these members, albeit at a much slower pace. Inevitably, terra cotta units that remain in association with corroded steel will fail over time as internal stresses continue to build. We can assume that in the future, effected elements will need further repair and/or replacement. For these reasons, in place repairs should not be considered to be permanent solutions. They will, however, go a long way in prolonging the life of the building.

RECOMMENDATIONS

Our report recommends that a long-term maintenance program be set up to monitor and systematically repair the terra cotta and brick masonry. The first step in achieving an effective maintenance program, a thorough investigation and documentation of the terra cotta and brick masonry, is under way. The owner's next step is to develop a strategy to continue the repair process.

This report reviews the existing conditions found to date, recommends repair strategies, and projects expectations for ongoing or future damage to areas receiving minimal or no repairs. Combined with our previous documentation, it provides a permanent record of terra cotta and brick masonry conditions as we understand them to date. Additional investigations may be required in the future as current conditions change or new problems surface.

We look forward to providing continued service to the MCDA and the Orpheum Theatre in the future in order to preserve this historic structure.

II. Execution of the Work: Phase One- Investigation and Repair Strategy

Work to be completed was categorized by priority level based on the architect's preliminary existing condition building survey. The following priority level descriptions were used to determine & identify the base bid & unit price scope of work intended for the project. Priority level "A" is considered part of the base bid. Unit prices were provided for priority levels "B" through "E" based on areas indicated on the elevation sheets. Priority levels "C" & "D" include individual terra cotta unit repair or replacement. Steel repair/replacement costs, structural design fees, and existing condition investigations by engineering staff were not included in the base bid or any other priority level unit pricing. Engineering services are contingent on conditions found during contractor investigation.

Priority Level A- Critical- conditions are a potential life safety hazard

There area a number of different areas that were assigned an "A" priority:

1. Corner "Towers": Specifically, the upper portion of towers including terra cotta cornices, dripstone band and brick masonry between cornice and parapet coping. These areas show signs of long term and repeated water infiltration. Extensive water penetration relating to coping, flashing and roof issues was addressed in the 1992 renovation. However, open joints and cracked masonry units were not addressed at that time and water has continued to enter the wall system.

All corner cornice units are damaged to some degree, presumably due to corrosion of steel anchor age. Through our investigation we have also discovered that structural steel, steel supporting not only the terra cotta cornice but the tower roofs as well, was also deteriorated to the point of structural inadequacy in at least in one location. Structural steel should be evaluated by a structural engineer in areas showing similar signs of deterioration.

All terra cotta corner cornice units should be evaluated for adequate anchorage conditions. Any loose units should be replaced and the steel support system evaluated. Any loose fragments should be mechanically anchored to sound substrate. As long as steel anchorage is structurally sound, the strategy is to repair these units in place. They are far removed from public view so patch and repair techniques will be less noticeable. It should be understood that the structural steel lookouts supporting these units have most likely suffered some degree of corrosion and will, over time, continue to deteriorate, although at a much slower rate now that joints have been repointed. These repairs should be considered temporary, a measure to help control the current budget, and it is assumed that replacement will be required at some point in the future. These areas should continue to be watched over time for signs of advancing deterioration. The worse case scenario would be that deterioration accelerates rapidly necessitating replacement of both steel and terra cotta cornice units in the near future.

a) South Tower- (Figs. 1-5 and Details 25-29/4-9).

- Terra cotta: One terra cotta corner unit was sacrificed in order to provide the architect and structural engineer access to structural steel supporting the cornice. It was discovered that the ends of this unit were open, probably to allow the masons access during installation. These open ended units allow water penetrating the terra cotta joints to flow directly onto steel sup ports within the interior cavity. Without end panels to stiffen the unit, they are also more vul nerable to stresses imposed by the expansion/contraction of adjacent, inherently stronger, closed units. Whereas these adjacent units are in reasonably good condition, corner units con sistently show signs of advanced deterioration. We suspect that all corner units are open ended and, therefore, at higher risk.

Original structural drawings detail the cornice supports as 2" x 3" double angles spaced at approximately 3'-0" on center. Architectural sections appear to show these angles supported at the bottom flanges of wide-flange beams within the wall. We were able to verify the size, configuration and general condition of the steel support angles assumed to be typical for the corner cornice units. We uncovered three double angles: two sets of 4" angles aligned with the outside edge of the unit, perpendicular to face of the wall; and one projecting diagonally at a forty five degree angle. The terra cotta unit was grouted solid to brick encasing the steel. This measure has provided marginal protection against water infiltration. The steel has a great deal of surface rust, which has caused fractures in the terra cotta, but otherwise appears well anchored and structurally sound. Exposed steel supports should be ground smooth to remove surface corrosion then treated with high performance coatings as specified in RFP#1.

This unit demonstrates the most severe damage of all corner units. We assume that since the lookout support steel is sound at this location, it will be in as good if not better condition at other more intact locations. Based on these observations we recommend that all other corner units be repaired in place.

- Brick Masonry: The face brick on the south side of the tower showed obvious physical displacement in the area corresponding to steel structure embedded in the wall. Mortar had deteriorated and bricks were loose to the touch. Bricks were removed to evaluate steel structure and will be reinstalled once repairs are made. The area above the cornice will be completely repointed.

- Steel Structural Framing: The structural integrity of the steel I-section supporting the roof was found to be compromised due to severe corrosion of the web. The structural design solution proposed in RFP-1 restores the capacity of the system by adding a new 8" steel channel, welded to the web of the deteriorated beam. Work was begun but was not completed by the end of the 2002 season. Although the exposed area was covered over the winter months, the steel beam condition should be reevaluated before work be gins. All visible rust and corrosion should be ground smooth down to solid material and a high performance coating applied as per specification section 09920 issued with RFP#1.

b) North Tower- (Figs. 9-10, Details 32 - 36, 40A, 40.2A/4-9).

- Terra cotta: At this time, based on observations made during the fall of 2002, we are recommending in place repair of corner units. One unit, however, demonstrates a higher degree of damage than the others. There is a large horizontal crack running the length of the unit (Details 34B, 40A, 40.2A/4-9). A physical inspection made during the fall of 2002 indicated that the unit was solidly anchored to the wall although the continued stability of this piece remains of some concern. The horizontal crack aligns with the support steel and it is possible that, with advanced deterioration, the lower half of the unit could easily free itself from the steel supports and fall to the sidewalk below. Based on observations made during the fall of 2002, and as a measure to conserve budget, we are currently recommending in place repair of this unit but only after stability is critically evaluated and assured. The repair should include mechanical fasteners that tie the separated bottom piece to solid steel or masonry substrate. This unit will most likely need replacement in the future.

A second cornice support detail is shown on the original structural drawings that ap pears to occur only at the Hawthorne side of the NE tower. It consists of 2 ½" x 3" double angles supported by an 8" channel located on the inside face of the wall. All terra cotta corner cornice units should be evaluated for adequate anchorage condi tions. Again, as a precaution, the bottom half and any other loose fragments should be mechanically anchored to sound substrate. Any loose units should be replaced and the steel support system evaluated.

- Brick Masonry: Face brick on the north side of the tower shows obvious physical dis placement in the area corresponding to steel structure embedded in the wall, a condition similar to that seen at the south tower. Mortar has deteriorated and there are a series of significant horizontal and diagonal cracks. Bricks should be removed as necessary to evaluate the underlying steel structure then reinstalled once repairs are made. Some steel repair/replacement may be required. The area above the cornice will be completely repointed and with the associated steel repair/replacement will be considered a long-term repair.

Fig.1: Terra cotta cornice at southwest corner of South Tower .

• This severely cracked and displaced terra cotta unit shows more advanced deterioration than is seen at more representative conditions at other corner cornice units.

Fig.2: Terra cotta cornice and band at southwest corner of South Tower .

• The corner unit of the horizontal band above the corner unit is also cracked and displaced. The location of the damaged terra cotta corresponds directly to deteriorated masonry and steel shown in Figs. 4-8. The most likely scenario is that long term water penetration from leaky parapet coping and flashing started the deterioration process at this corner.

Although the coping was repaired in 1992, the masonry and terra cotta joints were left open and water continued to infiltrate the wall system. Lack of maintenance has contributed significantly to the accelerated deterioration and potential failure at this location.

Fig.3: Terra cotta cornice after selective demolition.

• This unit was sacrificed in order to provide the architect and structural engineer access to the structural steel supporting the cornice. We discovered that the ends of this unit were open, probably to allow masons access during installation. These open ended units allow water penetrating the terra cotta joints to flow directly onto steel supports within the interior cavity. We suspect that all of the corner units are open ended and therefore much more susceptible to the effects of water infiltration.

Although corroded, the lookout support angles appear to be well anchored and structurally sound.

Fig.4: Exposed column connection at southwest corner of South Tower immediately above the terra cotta cornice.

• Top flange of structural steel beam is severely corroded. Delamination is evident across the entire length of the beam with rust jacking measuring 1”-1.5” thick.

• Exterior face of the web is severely corroded. In the original configuration, face brick was cut to fit around the beam flanges and the space between masonry and steel is grouted solid. Rust jacking at the web exerts tremendous force on the grout within the cavity breaking mortar bonds and displacing the brick masonry. Brick masonry was loose to the touch and could be easily removed by hand where forced away from the beam.

Fig.5: Partially exposed column connection at southwest corner of South Tower immediately above the terra cotta cornice.

• Riveted column connection appears to be structurally adequate. RFP#1 suggests a solution that provides additional support at the connection as a safeguard against continued corrosion.

Fig.6: Exposed beam at south face of South Tower immediately above the terra cotta cornice.

- Top flange of steel beam is severely corroded. Delamination is evident across the entire length with rust jacking measuring 1"-1.5" thick.

- Exterior face of the web is severely corroded along the entire length of the beam. Test holes were drilled through the beam web in order to determine current thicknesses. Measurements from a number of locations were taken in a in order to determine the remaining overall structural capacity of the beam. It was determined that the beam had deteriorated to a point where its structural integrity was questionable. We propose a solution to reinforce the beam in RFP #1.

- Steel corrosion at the bottom flange appears less severe.

Fig.7: Exposed beam at south face of South Tower immediately above the terra cotta cornice.

Fig.8: Interior face of south face of South Tower with approximate beam location indicated.

- The interior face of the wall, corresponding to the location of the beam shown in Figures 1-4, shows no signs of water damage. There are no damp areas, no masonry staining or rust streaking, no efflorescence, and no open joints or displaced masonry units. This is encouraging considering the conditions seen on the exterior face.

- Steel Structural Framing: The structural integrity of the steel I-section supporting the North Tower roof is also presumed to be compromised due to severe corrosion. The assumption is that the underlying condition will be as bad, if not worse, than that found at the South Tower. Investigation of this area by the structural engineer is necessary to determine the integrity of the structural system supporting the roof. The structural design solution proposed in RFP-1 restores the capacity of the system by adding a new 8" steel channel, welded to the web of the deteriorated beam. If this particular beam shows more advanced deterioration, the worse case scenario could involve total replacement of the steel member._ If no action is taken, the steel will continue to deteriorate, in spite of repointing efforts, and surrounding masonry and terra cotta materials will fail over time.

Fig.9: North elevation at North Tower showing condition of brick masonry above the terra cotta cornice.

Fig.10: Enlarged detail of terra cotta corner unit at north elevation at North Tower showing large horizontal crack.

Preliminary investigation revealed that the North Tower has a pattern of deterioration similar to that seen at the South Tower. Thorough investigation of this area by the architect and structural engineer is forthcoming.

• The terra cotta corner unit was evaluated by the contractor in the fall of 2002. It appears to be solidly anchored although the severe horizontal crack is a continuing concern. The stability of the bottom half of this unit should be reassessed and, as a precautionary measure against continued degradation, mechanically anchored. This piece will eventually need replacement.

• Brick masonry above the cornice has open horizontal joints corresponding to the top and bottom flange of the perimeter roof support beam. Masonry is bowed and presumed to be loose. Diagonal cracks at both corners are also visible.

• Steel corrosion is visible at open joints. The integrity of the structural beam is presumed to be compromised and in need of repair or perhaps even replacement.

c) Stage House Tower- (Fig. 11, Details 67 & 68/4-9).

- Terra cotta: At this time, based on observations made during the fall of 2002, we are recommending in place repair of these units. These units are not readily visible from the street so extensive repairs should not detract from the overall appearance of the building. Terra cotta corner cornice units should be evaluated for adequate anchorage conditions. Any loose units should be replaced and the steel support system evaluated. Any loose fragments should be mechanically anchored to sound substrate.

- Brick Masonry: The face brick on the east side of the corner pilaster has a significant vertical crack that potentially corresponds to steel structure embedded in the wall. A series of diagonal cracks on the north side-wall confirm the seriousness of the condition. Bricks should be removed to facilitate investigation by the structural engineer and reinstalled once repairs are made. Some masonry replacement may be required.

- Structural Steel Framing: The structural integrity of the steel at the corner is presumed to be compromised due to severe corrosion. The assumption is that the underlying condition will be as bad, if not worse, than that found at the south tower. However, in this case the structural member in question may involve the column as well as the beam. Investigation of this area by the structural engineer is necessary to determine the capacity of the structural system supporting the roof. The worse case scenario would involve total replacement of various steel members.

Fig.11: Enlarged detail of terra cotta corner unit at east elevation at northeast corner of the stage house showing large vertical crack.

• Vertical crack through mortar and brick masonry at east face of pier is aligned with the terra cotta joint at the cornice. Movement at the corner has caused large open joints between units. An old repair using some kind of bituminous compound has further damaged the terra cotta units.

• Another significant vertical crack, visible at the inside corner of pilaster, allows more water to enter the wall system.

• Additional masonry and mortar cracking is visible around the corner on the north facade.

2. Balcony on 9th Street:

We are currently limiting our efforts to concentrated areas exhibiting the worst long-term effects of prolonged water damage, specifically, the two end bays, including brick piers, and the second bay balustrade rail.

The entire balcony (i.e., not just terra cotta soffit units) appears to sag vertically at the end spans, a condition that may indicate deterioration of the primary structural support in these areas. Terra cotta soffit units also appear to demonstrate some vertical displacement between spans, possibly due to deterioration of anchorage and/or primary structural support. Deteriorated masonry at the balcony piers indicates ongoing water infiltration, which may be a cause for deterioration of the supporting structure.

Our investigation to date indicates that a substantial portion of the terra cotta steel anchorage system needs to be replaced, at least at the first or southernmost bay. External surface damage at the opposite end bay leads us to expect the same level of deterioration there as well. Both of these bays have external drains that may be a contributing factor to the advanced deterioration of the soffit units below. The second bay shows some isolated terra cotta balustrade rail damage. Other middle bays appear to be in reasonably good condition. These observations are conistent with the theory that the drains are a major source of water damage seen at the end bays.

Original structural drawings detail the balcony structural system as 4" x 3" double angles (spaced at approximately 2 feet) cantilevered from a 24" wide-flange beam. Architectural sections show a concrete topping slab. The as built conditions we have uncovered are slightly different. We have found that the outside pier is supported on a single cantilevered 8" channel lookout. Connection to a 12" channel, supporting the front edge of the balcony, is accomplished by riveting a 6"x6" angle to the web of each channel. Spacing of the lookout supports have not yet been determined. There is no evidence of a poured concrete slab to date.

Further inspection of the underlying structure will be required to verify the structural details, and determine the extent of deterioration and damage to the balcony. At this time, we have not yet been able to gain access to the structural members of the balcony. The balustrade is easily dismantled, top rail steel
anchorage is reasonably accessible and could be easily replaced. The rest of the balcony is highly
integrated and the remaining pieces are much more difficult to remove. A generalized worst case scenario would involve having to rebuild large portions of the balcony if structural steel members are found to have deteriorated beyond the point of repair. Replacement of structural steel would require complete removal of dripstone units, large decorative brackets and assorted soffit pieces. Completely dismantling large sections of the balcony would be a time consuming and expensive process that could potentially cause additional damage to vulnerable units already compromised..

The time and expense to dismantle the terra cotta, reconstruct the steel structural support system, rebuild the masonry piers, and reconstruct the terra cotta (assuming that a large portion of terra cotta units would have to be replaced, including at least some of the decorative support brackets which are the largest, most ornate, and therefore most expensive pieces on the building) goes beyond the scope of work defined for this project and could not be accomplished within the given budget.

Our strategy is to conduct a nondestructive investigation using fiber optic technology to assess the condition of buried structural steel systems. However, due to life safety issues associated with the location of the balcony over required theater exits, we will take a conservative approach to repairs in these areas and suggest that any locations showing extreme deterioration be opened up and investigated more thoroughly. Structural members that are deteriorated should be repaired or replaced. If anchorages alone are deteriorated, and supporting structure is sound, repairs to anchorage systems can be made with minimal impact by anchoring terra cotta units directly to the structure, bypassing deteriorated existing anchors.

Continued water infiltration will lead to further deterioration of the structural support, if not addressed. Waterproofing measures will be required in areas where flashing has failed and around drain repair/replacement.

a) Bay 1- South end (Figs. 13-24, New Details 1-2/5.1, Details 12-14.2/4-9)

- Terra Cotta: The balustrade at this bay was dismantled to allow for investigation of steel anchorage. Two replacement terra cotta pieces are required: the band unit at the base of the pier and one balustrade rail piece. If it is determined that primary steel supports and/or horizontal steel pins need to be replaced, it is likely that the three cracked terra cotta soffit panels would also require replacement. One of these soffit units has dropped nearly 3/4" since the investigation began in 2002 which leads us to believe that the back half of the cracked units are, at best, only marginally supported. This represents one of the most critical life safety issues facing the Orpheum Theatre since these soffit units are located immediately above the primary exit.

- Brick Masonry: The corner pier, as originally constructed, has a large, flat recessed surface where snow and water easily accumulate and subsequently saturate the brick masonry. Repeated freeze/thaw cycles have opened joints where horizontal and vertical surfaces meet allowing an even more direct route for deep water penetration. As a result, individual masonry units and mortar joints were cracked and extremely deteriorated and required extensive repairs and in some cases replacement. The pier was dismantled to allow investigation of steel anchorage supporting adjacent terra cotta units damaged as a result of long-term water infiltration from the pier. It will be rebuilt with existing and new brick once steel repairs are made. Horizontal surfaces of the brick pier will be lined with metal flashing to stop water saturation from above.

- Steel Anchorage: All vertical anchorage support rods, hangers and clips will need replacement. Most z-anchors can be removed by hand and will also need replacement. The continuous steel plate support for balustrade top rail needs replacement. Both the primary support channel and attached shelf angle show substantial delamination on exposed surfaces. Further investigation is required to determine their overall structural integrity. While it is entirely possible that these members can be salvaged, the worse case scenario would involve repair/replacement of these pieces. In addition, we have not yet been able to determine the structural integrity of the horizontal pins supporting the large soffit units. These soffit panels are cracked directly below the pin location and our assumption is that there is significant deterioration of these members. Replacing this portion of the anchoring system would require substantial deconstruction of the bay.

- Waterproofing: New waterproofing measures will be required where the balcony is being dismantled or where new drain installment is required. This will be covered in RFP-2R.

- Plumbing: The drain at the south end bay has been blocked for some time. This could be a primary source of water infiltration into the soffit below. The drain was cleared in the fall of 2002 but piping from the drain to the building should be investigated for damage. A new drain and strainer should be provided to help prevent future blockage. The worst case scenario would be that the piping is cracked or broken thus requiring replacement. This area is difficult to access and may require opening up an interior finished wall that would then have to be repaired and repainted to match existing finishes.

Fig.12: Balcony Bay 1 (south end) with cracked soffit units, April 2002.

• Terra cotta damage is most likely due to excessive water penetration at the brick masonry pier (See Figs. 15-18)and from a blocked balcony floor drain. Steel anchorage in this area was found to be extremely corroded (See Figs. 19- 24). Resulting rustjacking forces have caused a number of adjacent terra cotta units to shatter. For example, observable damage to the soffit units is presumably due to forces resulting from corrosion of a horizontal pin located immediately above the large soffit cracks. (See Detail 1/5.1 included in this report)

Fig.13: Balcony Bay 1 (south end) with displaced soffit unit, May 2003.

• Then terra cotta soffit unit to the right has dropped nearly 3/4" over the winter causing concern for the overall stability of the back half of these units.

Fig.14: Balcony Bay 1 (south end) showing damaged terra cotta.

• Severe terra cotta damage is limited to areas adjacent to the water-damaged masonry pier. The baluster rail, showing significant vertical deflection, is very unstable and can be easily displaced laterally by simply pushing on it.

Fig.15: Balcony Bay 1 (south end) showing the flat recessed top surface of the masonry pier.

Fig.16: Balcony Bay 6 (north end) showing a similar flat recessed top surface and a thin layer of concrete to provide protection and improve drainage.

• Water saturating the exposed horizontal surfaces of flat recessed top penetrates deeply into the lower section of the pier through open mortar joints or runs down the face of the masonry pier. Water eventually reaches the steel anchorage system supporting the terra cotta. We suspect that cantilevered structural steel supporting the balcony itself may also be deteriorated to some degree.

Fig.17: Balcony Bay 1 (south end) .

• Repeated freeze/thaw cycles and constant water flow patterns have eroded both mortar and masonry. Wide open joints allow excessive water penetration into the masonry assembly which in turn causes deterioration of steel anchorage buried in the system. The recessed flat portion will be flashed with metal and the pier rebuilt and repointed once steel and terra cotta repairs are made.

Fig.18: Balcony Bay 1 (south end) showing effects of long term water damage.

• The terra cotta baluster top rail is supported on a 3” x 1/4” continuous steel plate anchored at the ends by 5/8” vertical rods embedded in the masonry piers. Masonry joints between rail units and balusters were typically found to be open leaving the steel plate exposed. Delaminated sections of the corroded plate had measured thicknesses up to 3/8”.

The balustrade was extremely unstable this entire section was dismantled by hand with little effort.

Fig.19: Balcony Bay 1 (south end) showing steel support for terra cotta baluster top rail.

• Terra cotta is shattering as a result of increasing stresses from steel corrosion. Large open cracks provide additional avenues for direct water penetration. Snow and ice infiltrate and accumulate around the baluster toe rail. Repeated freeze/thaw cycles, in combination with the effects of rustjacking of steel supports below, cause the balustrade to heave upwards adding additional stress to the system. This movement breaks down the mortar joints between terra cotta units thus allowing even more water to enter the system. The cycle continues and degradation of both terra cotta and steel accelerates.

Fig. 20: Balcony Bay 1 (south end) showing fractured terra cotta baluster bottom rail.

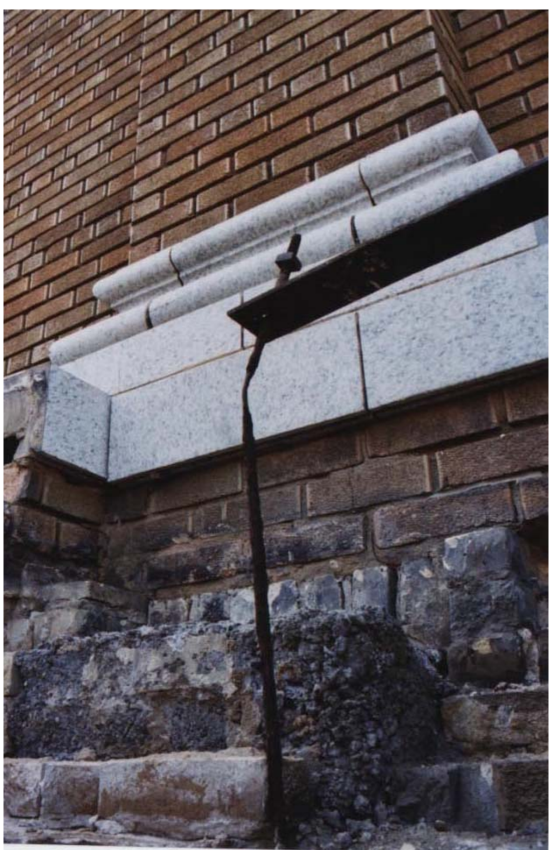
• The broken terra cotta band unit at the base of the pier was removed to provide access to buried steel supports. The severely corroded vertical rod represents the lower portion of the anchor support for the baluster top rail. Originally 5/8” thick, it measured less than 1/8” thick in some areas and was brittle enough to break by hand. Extreme delamination (1”-1-3/4” thick) of the top surface of the primary structural support channel can be seen to the right. The steel strap clipped to the channel and the 1/2” vertical rod it supports are also seriously corroded and in need of replacement. Dripstone Z-anchors were either missing or could be removed by hand.

Fig.21: Balcony Bay 1 (south end) showing steel support for terra cotta baluster bottom rail.

Fig.22: Balcony Bay 1 (south end) showing steel support plate for terra cotta baluster top rail at intermediate pier.

• Stresses from rustjacking and upheaval of the baluster rail system from below have caused deformation of the steel plate. The displacement ranges from 1-1/2"-1-3/4".

Fig.23: Balcony Bay 1 (south end) showing steel support plate and top of embedded vertical rod anchor for terra cotta baluster top rail.



• The deteriorated masonry pier was deconstructed to provide access to buried steel supports. The severely corroded vertical rod is the main support for the baluster top rail. Originally 5/8" thick, it measured less than 1/8" thick at various locations and was brittle enough to break by hand.

Anchors below the dripstone band level have not yet been investigated. Because of the observable damage to terra cotta, the assumption is that these anchors will also show signs of deterioration. Nondestructive investigation, using a fiber optic boroscope, will be used to evaluate dripstone vertical rod anchors, horizontal pins, and structural steel components.

All accessible steel anchors and plates showing signs of corrosion should be replaced with new stainless steel members. Structural steel repairs and replacement of highly integrated anchors will be evaluated on a case by case basis.

Fig.24: Balcony Bay 1 (south end) showing steel support plate and exposed vertical rod anchor for terra cotta baluster top rail.

Detail 1/5.1....anchorage @ balcony

Detail 1/5.1....anchorage @ balcony

b) Bay 2 (New Detail 3/5-1, Details 16 &16.1/4-9)

- Terra Cotta: Three replacement terra cotta pieces are required for the balustrade rail.

- Brick Masonry: Adjacent piers appear to be in good condition.

- Steel Anchorage: It is likely that some vertical support rods, hangers, clips and z-anchors will need replacement. The continuous steel plate support for balustrade top rail will be replaced. Further investigation is required to determine overall structural integrity of the steel anchorage system below the damaged terra cotta units. The worse case scenario would involve repair/replacement of primary support channel and attached shelf angle. In addition, we have not been able to determine the structural integrity of the horizontal pins supporting the large soffit units. At this time there is no physical damage visible at the soffit. There is no drain in this bay and it is possible that there has been less water penetration in this bay than in the adjacent end bay.

- Waterproofing: Existing flashing will be repaired as per RFP-2R.

c) Bay 6 (New Detail 4/5-1, Details 21-23/4-9)

- Terra Cotta: The balustrade will be partially dismantled to allow for investigation of steel anchorage. One replacement terra cotta piece is required at the band unit at the base of the pier. Balustrade rail pieces appear to be intact. If it is determined that primary steel supports and/or horizontal steel pins need to be replaced, it is likely that one cracked terra cotta soffit panel and possibly a second soffit panel, one showing some discoloration, would also require replacement.

- Brick Masonry: The corner pier was cracked and deteriorated. The end pier will be dismantled to allow investigation of steel anchorage. It will be rebuilt with existing brick once steel repairs are made. Some replacement may be required.

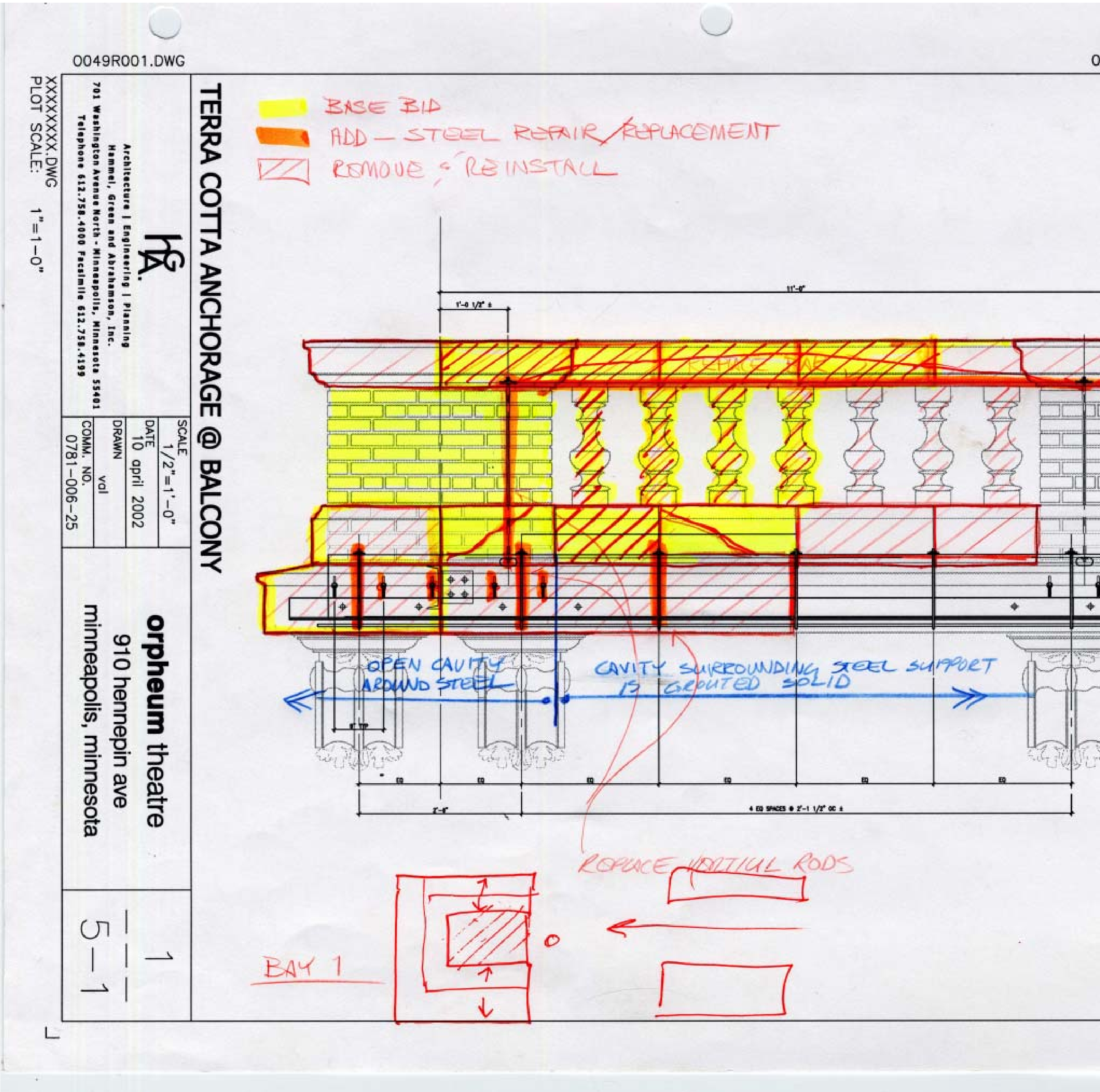
- Steel Anchorage: It is likely that some vertical support rods, hangers, clips and z-anchors will need replacement. The continuous steel plate support for balustrade top rail will be replaced. Further investigation is required to determine overall structural integrity of the steel anchorage system below the damaged terra cotta units. The worse case scenario would involve repair/replacement of primary support channel and attached shelf angle. In addition, we have not been able to determine the structural integrity of the horizontal pins supporting the large soffit units. One soffit panel is cracked directly below the pin location and our assumption is that there is significant deterioration of these members. Replacing this portion of the anchoring system would require substantial deconstruction of the bay.

- Waterproofing: New waterproofing measures will be required where the balcony is being dismantled or where a new drain installment is required. This will be covered in RFP-2R.

- Plumbing: The drain at the north end had been blocked for some time. This could be a primary source of water infiltration into the soffit below. The blockage was cleared in the fall of 2002 but water leaked through the terra cotta soffit. This indicates that the piping from the drain to the building is cracked or broken and therefore requires replacement. In addition to the new piping, a new drain and strainer should be provided to help prevent future blockage. This is the worst case scenario since this area is difficult to access and may require opening up an interior finished wall that would then have to be repaired and repainted to match existing finishes.

d) Bays 3-5 (Details 19-20/4-9)

- Terra Cotta: There were open joints and a number of displaced units in these bays so the potential for long term water penetration and subsequent steel anchorage deterioration does exist. However, there were no signs of extensive water damage to terra cotta units themselves. To conserve available funds, additional investigation and steel anchorage replacement is not being considered for these bays at this time. All terra cotta was repointed in the fall of 2002 but these areas should be inspected on a yearly basis for signs of advancing deterioration.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BASE BID
ADD — STEEL REPAIR/REPLACEMENT
REMOVE & REINSTALL
11'-0"
1'-0 1/2" ±
OPEN CAVITY AROUND STEEL
CAVITY SURROUNDING STEEL SUPPORT IS GROUTED SOLID
2'-6"
4 EQ SPACES @ 2'-1 1/2" OC ±
REPLACE VERTICAL RODS
BAY 1
TERRA COTTA ANCHORAGE @ BALCONY
Architecture | Engineering | Planning
Hammel, Green and Abrahamson, Inc.
701 Washington Avenue North - Minneapolis, Minnesota 55401
Telephone 612.758.4000 Facsimile 612.758.4199
SCALE 1/2"=1'-0"
DATE 10 april 2002
DRAWN vol
COMM. NO. 0781-006-25
orpheum theatre
910 hennepin ave
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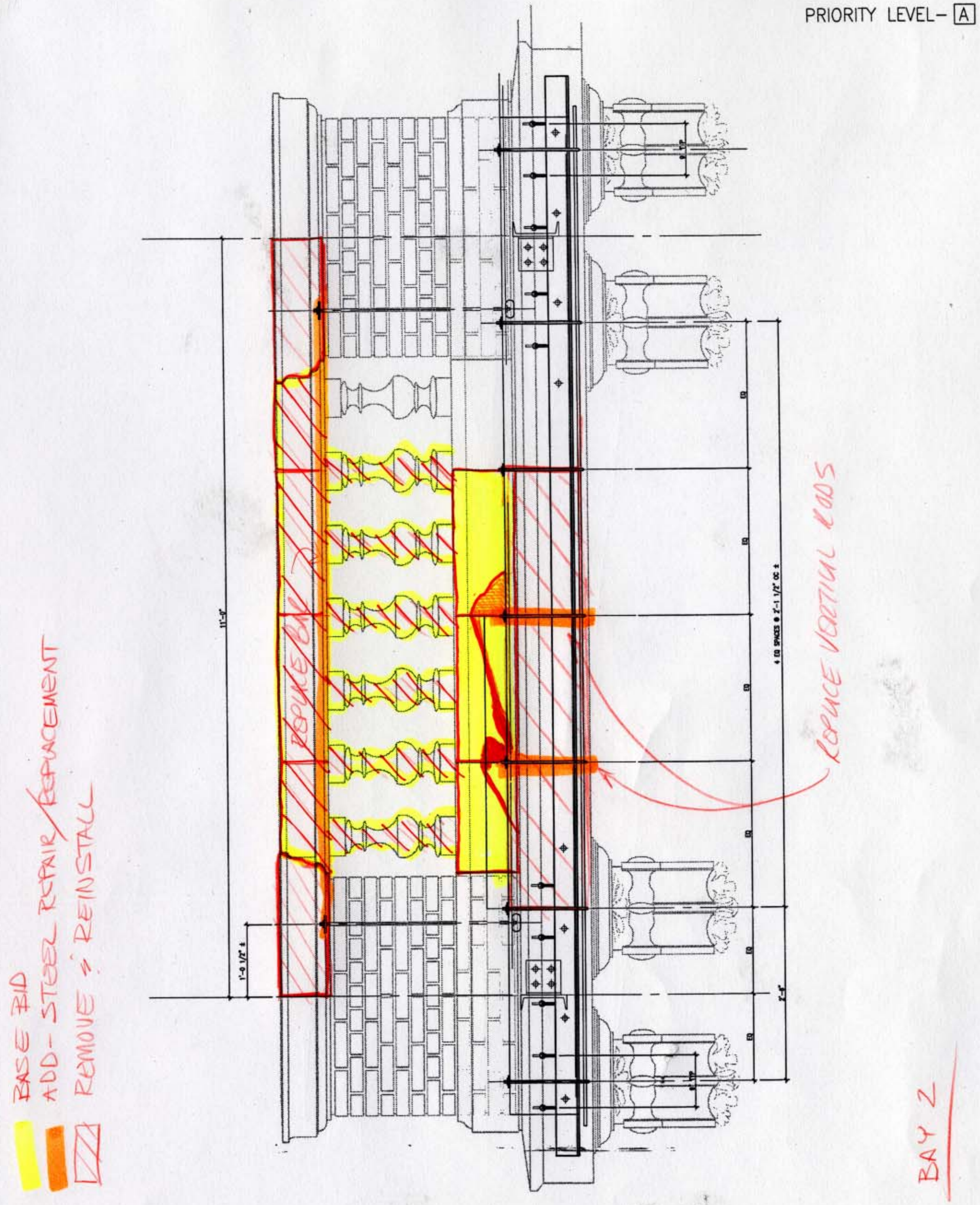

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SCALE	1/2"=1'-0"
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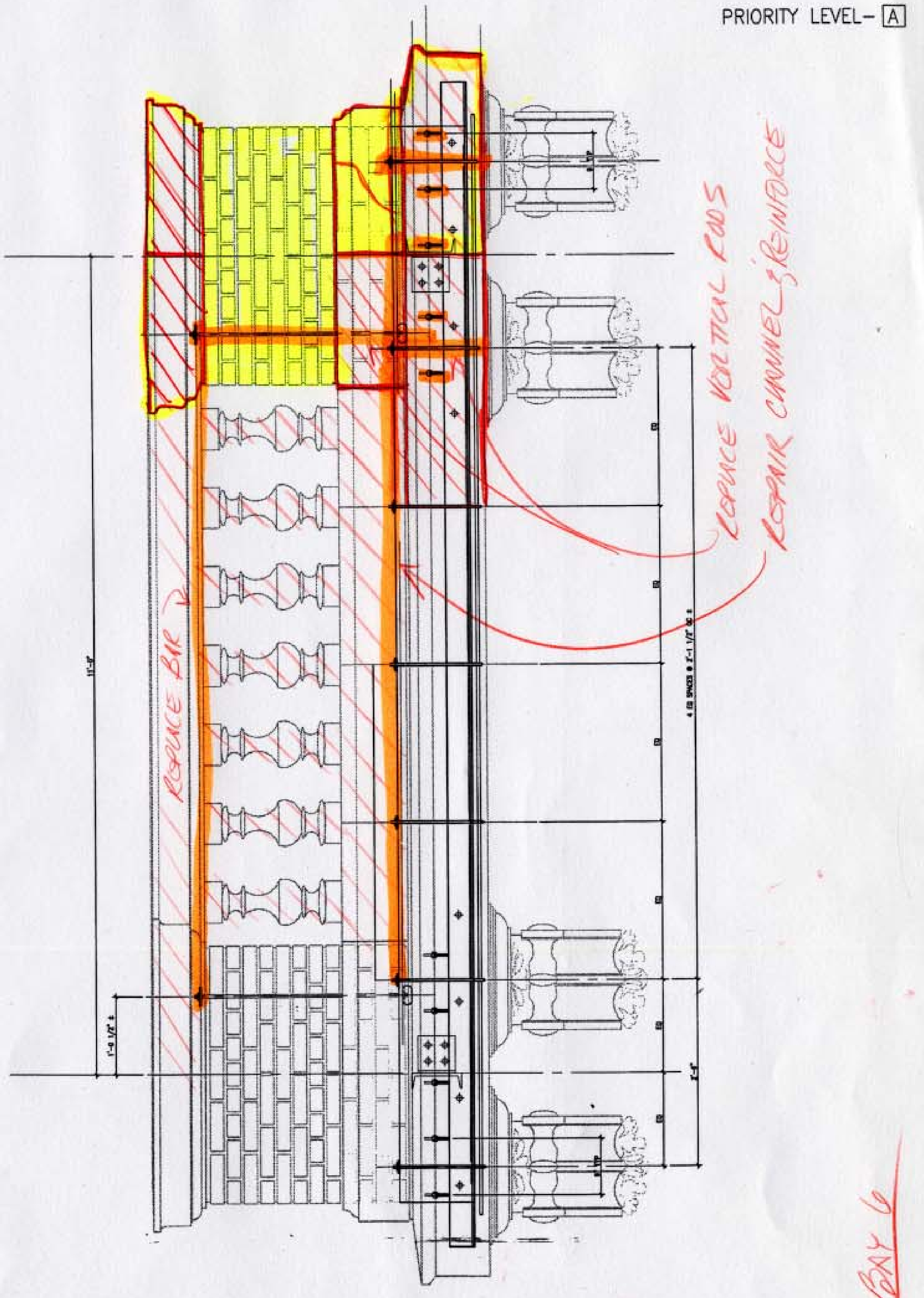
PRIORITY LEVEL- A



TERRA COTTA ANCHORAGE @ BALCONY

HGA Architecture | Engineering | Planning Hammel, Green and Abrahamson, Inc. 701 Washington Avenue North - Minneapolis, Minnesota 55401 Telephone 612.758.4000 Facsimile 612.758.4199	SCALE 1/2"=1'-0" DATE 10 april 2002 DRAWN val COMM. NO. 0781-006-25	**orpheum** theatre 910 hennepin ave minneapolis, minnesota	1 5-1

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3. Cornice along 9th Street Faded (Figs. 25-32, Detail 30 - 31.1/4-9)

- Terra Cotta: Many terra cotta cornice units are badly damaged. Because of the distance from which they are seen by the public, the preference is to patch and repair these units in place. This is considered a temporary repair and it is likely that replacement will be required at some point in the future. One of the more seriously damaged units may have to be sacrificed in order to determine the condition of the steel anchorage system. The worst case scenario would involve replacement of a large number units due to advanced deterioration, and subsequent replacement, of the steel support framework.

- Steel Anchorage: There is continued concern for the condition of steel angle lookouts supporting the cornice. Long-term water infiltration, visible both inside and out, has likely contributed to the deterioration of the cornice support system. Badly corroded and delaminated steel members are visible on the inside face of the exterior masonry wall at the third floor level. The original plaster finish has water damage over the majority of the wall area. In those areas where the plaster has been removed, the exposed ends of the steel shapes show significant corrosion and delamination but appear to be T-shaped members or double angles, with an approximate overall dimension of 3.5" x 3.5". They are spaced at approximately two feet and located at the approximate elevation of the cornice, indicating that they are most likely part of the structural support for the terra cotta.

  The original structural drawings detail the terra cotta cornice support as 4" wide-flange sections, spaced at approximately 5 feet, cantilevered from a supporting 20" wide-flange beam. This is inconsistent with the condition visible at the interior face of the wall. However, the structural drawings for the tower cornices detail the supports as 2" x 3" double angles spaced at approximately 3 feet, and architectural sections appear to show these angles supported at the bottom flanges of wide-flange beams within the wall. This is consistent with the visible conditions described above, indicating this system may have also been used at the main cornice above the balcony.

  Due to evidence of extensive water infiltration, the structural engineer is recommending that the support systems for the cornice be evaluated. It is likely that damage is limited to the exposed surface of the steel section, however, further investigation is required to determine the overall structural integrity of the primary steel support and anchorage systems as well as the masonry through which steel is embedded. Evaluation in this area is critical to insure public safety.

  The investigation should begin with the area showing the most advanced physical deterioration. It may be possible to use nondestructive fiber optic investigation, otherwise, brick should be removed around exposed steel to verify attachment of the double angles to a supporting beam within the wall, and the extent of deterioration of the supporting members determined. Where plaster remains, a portion of the plaster and brick should be removed, and the configuration and condition of the supporting members similarly verified. If the steel is found to be sound, no further investigation will be done at this time. The assumption is that steel conditions will be as good if not better than that seen in areas with more severe water damage. However, if the steel at either location is determined to be compromised, further investigation should proceed until stable conditions, as required by the structural engineer, are found.

The worse case scenario would involve repair/replacement of primary support angles along the length of the cornice. If the visible condition is an indication, and if these steel members truly are supporting the terra cotta, it is highly likely that some repair or replacement will be required.

Fig.25: Damaged terra cotta cornice units along 9th Street main cornice viewed from below.

- Mortar joints were typically open along the entire length of the cornice. Most of the terra cotta damage is concentrated at the joint locations, probably due to water entering the joint cavity and subsequent freeze/thaw expansion/contraction. Other damage is observable at head conditions above third floor windows, Fig.27.

Although corrosion at steel angle lookouts is expected to some degree, it is encouraging that individual units do not appear to be displaced, Fig. 28.

Fig.26: Damaged terra cotta cornice units along 9th Street main cornice viewed from above.

Fig.28: Terra cotta cornice along 9th Street

Fig.27: Damaged terra cotta bottom band cornice unit above third floor window

Fig.29: Corroded steel angles, presumably serving as primary structural support for the 9th Street main cornice, can be seen where damaged plaster has fallen away from the interior face of the wall.

Fig.30: Old interior water damage from leaking tile roof and gutter detail.

Fig.31: Old interior water damage from leaking tile roof and gutter detail. Terra cotta cornice and lintel units above this particular window are cracked.

Fig.32: Old interior water damage from leaking tile roof and gutter detail showing extent of damage.

4. Projecting Lintel @ Hawthorne Avenue (Details 41A, 43-45 /4-9)

   - Terra Cotta: The terra cotta lintel units show signs of significant mechanical and long-term water damage. The damage is so extensive that complete replacement has been assumed for the soffit and mid-band units with thirty percent replacement anticipated for the dripstone band. The worst case scenario would involve complete replacement of the dripstone band.

   - Brick Masonry: The brick masonry immediately above the lintel appears to be in fairly good condition. One would expect to see more pronounced evidence of degradation, i.e. cracked masonry and broken joints, in this area if the primary steel support structure was indeed failing. The soundness of the existing condition is encouraging. There are areas of brick just below the door thresholds above that show signs of deterioration. Although these conditions are considered a 'C' level priority, they could also be a contributing source of water penetration to the wall and lintel system below.

   - Steel Anchorage: The lintel has been supported on wood 2x framing since the 1992 renovation. Damage to the terra cotta cladding is a result of mechanical damage from early fire escapes and from severe deterioration of the steel structural framing that supports it. The bottom flange and a portion of the web of the primary structural support for the lintel are visible through a large, open masonry joint in the terra cotta. Substantial deterioration of the visible area of this structural member is evident, including one to two inches of vertical deflection along the flange length, and corrosion of the steel with some delamination.

     The original structural drawings show a 24" wide-flange section with a 12" wide bottom flange reinforcing plate at the lintel location, and architectural sections show the terra cotta along the Hawthorne façade supported directly on the main beams. Structural drawings also show a second 24" floor beam framing into the main lintel beam, which could potentially complicate repairs. The conditions of the remaining elements of the lintel support are not visible, but it is reasonable to assume similar deterioration has occurred as a result of long-term water infiltration.

The terra cotta should be removed to verify the configuration and condition of the structural support. Based on the visible indications of steel damage and the poor condition of the supported terra cotta, it is likely that the structural support for the lintel will require substantial reinforcement or replacement prior to repair or replacement of the terra cotta. Material and structural design services for replacement steel were not part of the bid package. Design requirements will be clarified after further investigation once the existing condition is dismantled.

Fig.33: Projecting lintel at Hawthorne Avenue elevation braced on wood timbers. The temporary supports date back to the 1992 renovation.


Fig.34: Corner of projecting lintel at Hawthorne Avenue.

The east corner at the lintel is extremely damaged, the soft terra cotta core is exposed, and water is easily channeled into both the wall system below and the adjacent lintel. Steel anchors, the one shown here is from an early fire escape, were hammered through the terra cotta in a number of locations. Mechanical damage caused by this action is one of the sources for water penetration.

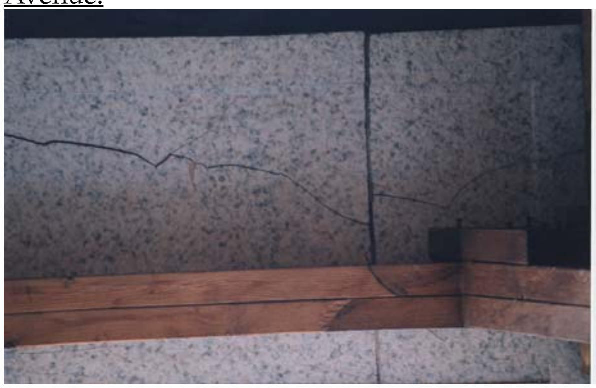
Fig.35: Soffit of projecting lintel at Hawthorne Avenue viewed from below.

Every soffit unit has a severed horizontal crack, continuous with those of adjacent units, oriented relative to the direction and location of the steel beam supporting the lintel system. As the beam and attached plate corrode and deflect, stresses.


Fig.36: Deflection at lintel steel support visible through open joint betweem terra cotta soffit and lower band units.

The bottom flange and a portion of the web of the primary structural support for the lintel are visible through a large, open masonry joint in the terra cotta. Substantial deterioration of the visible area of this structural member is evident, including one to two inches of vertical deflection along the flange length, and corrosion of the steel with some delamination.


Fig.37: Severely corroded steel support visible through open joint betweem terra cotta soffit and lower band units .

Substantial deterioration of the visible area of this structural member is evident, delamination of the steel is exerting forces on the terra cotta causing it to fracture and spall. Deterioration will proceed rapidly toward eventual failure once conditions reach this level.

5. Arched Openings @ Balcony (Detail 15, 17 & 18/4-9)

- Terra Cotta: The terra cotta window surrounds at the jambs, Greek key and flat panel lintel units are being replaced entirely with new terra cotta. Many of these units are broken completely through exposing the core and allowing water to freely enter the wall system. This could also be another major source of water penetration into the balcony soffit below.

- Steel Anchorage: There has been no investigation of steel support members to date. The worst case scenario would involve replacement of steel supports at the window jambs or lintels. This would require window removal and shoring of the masonry arch.

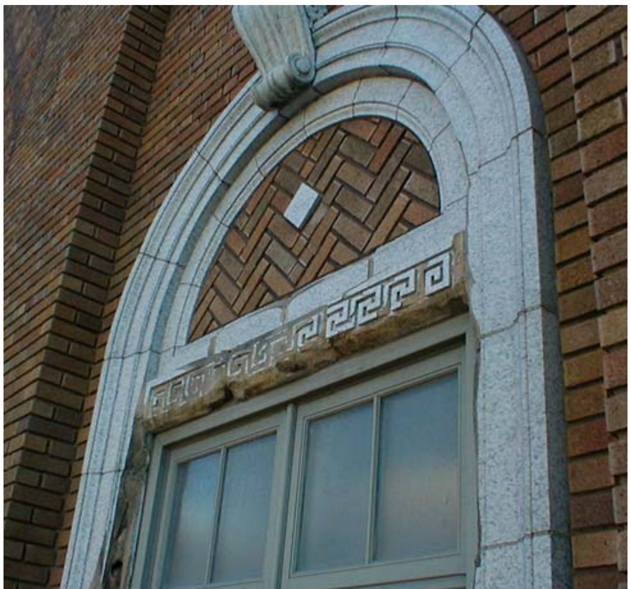

Fig.38: Severely damaged terra cotta window surrounds with exposed core at left jamb. Bay 1, south end

Fig.39: Severely damaged terra cotta window surrounds- Bay 1, south end

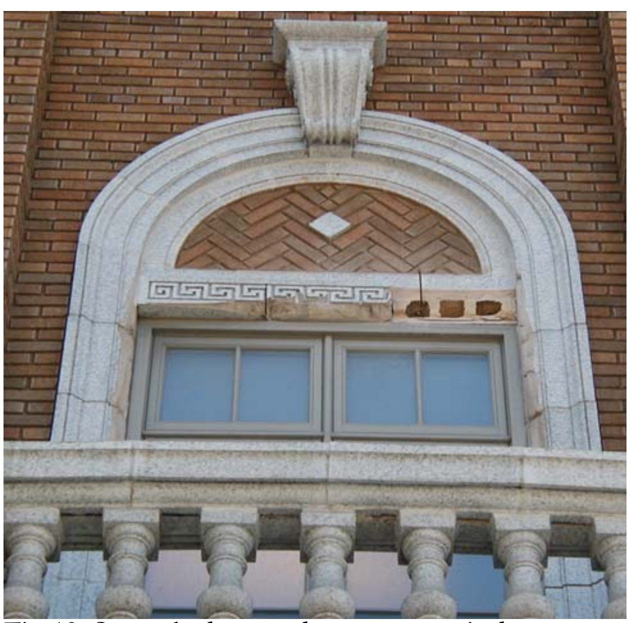

Fig.40: Severely damaged terra cotta window surrounds. The Greek key unit to the right was removed by the contractor and sent to the manufacturer as a template. Bay 2, south end.

6. Dripstone Corner Band @ First Level (Details 37B, 38, 40B & 40.1/4-9)

- Terra Cotta: The terra cotta corner units at the first level dripstone band show signs of significant long-term water damage. There are a number of damaged and displaced units. The damage shows a correlation with the wide vertical masonry crack (repaired in the fall of 2002) that ran the full height of the building on the 9th Street side of the corner. Water entering the masonry crack was channeled to the top surface of the horizontal terra cotta band saturating these units and the steel anchorage supporting them.

  Our assumption is that the relief of building stresses, manifested as a vertical crack in the masonry and adjacent terra cotta, has stabilized at this point and that no further movement will occur. However, this area should be carefully monitored over time. If a crack begins to reform, in depth structural analysis of this area should be performed. The worse case scenario would be discovery of an underlying structural problem at the corner. Now that the open joints and cracked masonry have been repaired, the source of water penetration has presumably been mitigated. This should help minimize further deterioration of the terra cotta and associated steel anchorage. Because of the difficulty involved in selectively removing terra cotta units, the preference at this time is to patch and repair these units in place to avoid further damage to the surrounding masonry. It should be understood that the steel anchorage for terra cotta in this area has most likely suffered some degree of corrosion and will continue to deteriorate, although at a much slower rate, over time. This is considered a temporary repair to help control the current budget and it is assumed that replacement will be required at some point in the future. This area should continue to be watched for signs of advancing deterioration.

Fig.42: The second dripstone unit is displaced outward indicating that the steel anchors may have broken free and are no longer supporting the unit.

Fig.41: The second dripstone unit is displaced and the third fractured, the fragment ready to fall (Spring 2002)

Fig.43: One year later, the fragment has spalled off (Spring 2003)

7. Railing Repair: (55/4-9)

Minimal railing repairs along Hawthorne Street exist stairs will be performed as a temporary measure to insure public safety. The concrete retaining walls are in an advanced stage of deterioration but at the owners request were assigned a lower priority and are therefore not included in the base bid. It is possible that the concrete will not be able to adequately support the recommended repairs to the railing system. The worse case scenario would require upgrading the priority level of the retaining walls and including concrete repair in the current scope of work.

Fig.48: Typical railing support at exit areaway on Hawthorne Avenue.

Fig.49: Concrete retaining wall at exit areaway on Hawthorne Avenue.

<u>Priority Level B-</u> High priority- conditions present architectural and/or structural issues requiring immediate attention to prevent further damage that could easily become a life safety issue in the near future.

- Alt-1: Repair the structural masonry crack running the entire height of the building at the northeast corner of the 9th Street façade. (Detail 48/4-9)

  This work was completed by the contractor without acceptance from the owner. Although an alternate, this was am important repair because the existing condition was a major contributing factor to the water damage and corrosion observable at the corner dripstone, described previously in Priority Level A Section 6, and water table below. Although this corner has presumable suffered some degree of deterioration, preventing additional water from penetrating deep into the wall system should buy some time before more aggressive repairs are required. Again, this is one area that should be monitored for physical changes or other signs of advancing deterioration.

- Alt-2: Repair (6) impost blocks and springers along the Hawthorne Avenue façade. (Details 48.1, 50.1, 51.1, 58.1 & 62.1/4-9)

  This is the most serious condition outside of the Priority Level A life safety category. Damage to brick masonry, terra cotta and structural steel is already severe at these locations and will continue to accelerate with each passing season. As conditions worsen, one by one, or as a group, these areas will eventually qualify as life safety hazards themselves. Considering the advanced state of deterioration, this point will probably be reached in the near future.

  Due to the inaccessibility of these areas, an in depth investigation has not yet been made. Once the contractor moves operations to the Hawthorne Avenue facade, it is suggested that the investigation be expanded to include a sampling of springers and impost blocks so that the severity of the situation can be assessed. The worse case scenario is that the inspection shows damage to be worse or more dangerous than expected. The condition of the steel is a huge concern since advanced corrosion is already visible from a vantage point across the street, a condition that in some ways parallels that seen at the projecting lintel previously described in Priority Level A, Section 4.

  Repair or replacement of steel in these areas potentially require extensive shoring, brick masonry removal, terra cotta removal and replacement, masonry reinstallation with some replacement, and repointing. Repairs of this magnitude exceed the scope of work and available budget for this phase. However, if no action is taken, degradation will proceed rapidly toward eventual failure. Obviously, delaying action now will necessitate more extensive repairs; damaged areas will increase in size and scope; more brick and terra cotta units will be involved in the repair/replacement process; steel may no longer be salvageable thereby forcing more extreme repair/replacement techniques. The bottom line is that the longer the damaged conditions are left untreated, more historic material will be lost in the interim, and significantly higher associated repair costs will be incurred in the future.

Fig.44: Impost block and masonry arch springers at the Hawthorne Avenue facade (From Detail 50.1/4-9)

This bay is at an early stage of deterioration. The joint at the structural steel support member, located two courses above the terra cotta band, is open. The terra cotta units appear to be intact but joints between units are open. There are many open brick masonry joints immediately below the terra cotta. Water is able to easily enter the wall system. Before long this bay will resemble conditions observed in Fig. 45.

Fig.45: Impost block and springer @ Hawthorne Avenue facade (From Detail 58.1/4-9)

This bay is starting to show more advanced signs of deterioration. The joint at the structural steel support member is open. One terra cotta unit is cracked and joints between units are open. There are many open brick masonry joints immediately below the terra cotta. Again, water is able to easily enter the wall system. Corroding steel anchors are expanding thus causing damage to nearby terra cotta. Before long this bay will resemble conditions observed in Fig. 46.

Fig.46: Impost block and springer @ Hawthorne Avenue facade (From Detail 48.1/4-9)

Damage to this bay is severe. The joint at the structural steel support member is open and the corroded steel member is clearly visible. Several bricks above the terra cotta band are crushed. The adjacent terra cotta unit is severely cracked and the fragmented piece threatens to dislodge and fall to the sidewalk below. The joints between terra cotta units are open and the units appear to be misaligned indicating possible anchorage failure. From this point forward, deterioration will advance rapidly and soon this bay will resemble conditions observed in Fig. 47.

Fig.47: Impost block and springer @ Hawthorne Avenue facade (From Detail 58.1/4-9)

This bay is well on its way to becoming a potential life safety hazard. The joint at the structural steel support member is open and the corroded steel member is clearly visible. There appears to be substantial delamination and deformation of the steel member. Several bricks above the terra cotta band are missing. The adjacent terra cotta unit is shattered. The joints between terra cotta units are open and the units are obviously displaced indicating possible anchorage failure. Deterioration at the exposed section will continue to accelerate, ultimately affecting the surrounding materials.

Priority Level C- Moderate priority- conditions present architectural issues that are problematic but not immediately threatening. Delayed repair will cause additional deterioration & increased repair costs.

- Alt-3: Repair (3) door sills and repoint brick masonry below at Hawthorne Avenue façade. (Details 51, 51.1B, 73A-74/4-9)

  Water is leaking into the masonry wall at the sill level. This could be a potential contributing factor to the deterioration of the lintel in one case and to the poor condition of the terra cotta dripstone in another. Due to the inaccessibility of these areas, an in depth investigation has not yet been made. Further investigation may reveal unexpected conditions that may require more immediate attention.

  There are an additional (4) doors on the south court elevation that share a similar condition.

Fig.50: Threshold above dripstone band on Hawthorne Avenue.

Fig.51: Damaged masonry below threshold at south court. This level of deterioration is typical for all doors on both the Hawthorne Avenue and south court facades.

Priority Level C- Moderate priority- conditions present architectural issues that are problematic but not immediately threatening. Delayed repair will cause additional deterioration & increased repair costs.

- The remainder of the C-level repairs (Details 46-75/4-9) involve terra cotta that, although severely damaged, is either more easily accessible or less threatening to public safety. The severity of the conditions should not be underestimated. The observed damage although already extreme in some cases, will of course continue to worsen over time even in those areas where damage is still moderate. Isolated damage will begin to spread involving more and more adjacent units and increasingly larger areas of impact . In time, these too will evolve into potential life safety hazards and will require aggressive repair or replacement at a higher premium.

Fig.51: Damaged terra cotta water table along Hawthorne Avenue.

Although this area will never pose a threat to public safety, continued degradation will affect not only the overall appearance of the building but it's performance as well. Much of this damage is probably caused by mechanical impact from shovels, snowblowers, and differential sidewalk movement.

Fig.52: Damaged terra cotta water table at exit areaway along Hawthorne Avenue.

Fig.53: Enlarged view of damaged terra cotta water table unit.

<u>Fig.54-61: Damaged terra cotta dripstone units along Hawthorne Avenue that were assigned a C-Level Priority rating.</u>

Some units are more severely damaged than others, some have been previously patched, others are shifting out of alignment. The life-span of many of these units could be extended with minor repairs, however, if no action is taken their condition will worsen and replacement will be inevitable.

There are many areas yet to explore and many conditions that remain unknown. Regular maintenance should be continued after this phase is completed. Conditions should be closely monitored and changes documented during the time span between additional restoration phases. As funds become available, repairs to the historic terra cotta should be re-prioritized and quickly implemented to insure the continued viability of a valued cultural resource. Restoration will no doubt be an ongoing and lengthy process, one that will likely take continued effort and financial support over many years. It is our hope that the information contained within this report will provide a sound starting point and serve as a resource to help guide future efforts.

III. Maintenance Strategy

Historic structures, such as the Orpheum Theatre, form an integral part of the collective memory of our community. As cornerstones of our cultural traditions, they represent the aspirations and dreams of those who sought to make Minneapolis a better place for all to live. The privilege of owning and preserving historic properties is a tremendous responsibility and maintaining an older building, especially one with historic designation, requires ongoing care and attention in terms of both physical and financial commitment. No building is static and, subject to the natural processes of time and weather, these living relics from the past- filled with history and romance, will continue to evolve and contribute as long as they remain standing. A vigilant maintenance program would serve to help protect and preserve the historic structure, thereby safeguarding the owner's investment, and insuring that an invaluable public asset will survive to inspire future generations.

In order to preserve a historic structure, it is first necessary to identify, then determine the cause or causes of the deterioration. Too often only the symptoms are treated and the real source of the problem is never fully understood. Quick-fix maintenance attempts and poorly chosen repair tactics will often either aggravate the original problems or create new conditions that ultimately lead to further deterioration and additional expenditures. More commonly perhaps, materials and systems are ignored until they become problems. This piecemeal approach is not acceptable if the building is to survive intact.

Developing a successful maintenance strategy is critical for the protection of any building. Typically, maintenance cycles can be broken down into four distinct phases: inspection, planning, scheduling, and implementation. In the first step, problems and symptoms are recognized, analyzed and monitored as required. Conditions are then researched, prioritized and documented. Specifications and bidding documents are developed during the planning phase and estimates pertaining to the scope of work be completed are solicited. As part of the implementation phase, researching qualified contractors and/or acceptable craftsmen plays a significant role in assuring quality work.

Identifying problems during the first two phases of the cycle is the most critical aspect of any maintenance program. The most successful maintenance programs are those designed to treat the structure as a whole, placing emphasis on identification of all possible causes of deterioration. However, if a program is to be most effective it should not only define existing problems and detail corrective measures, but should also predict continuing or hidden problems. To accomplish this level of programming, a thorough understanding of the building is required. Developing a maintenance strategy is an adaptive learning process that must be responsive to continual discoveries made over time.

Deterioration is seldom due to one set of circumstances alone. It may be due to a whole series of unrelated situations, or it may be more of a chain reaction. Generally, it is a combination of both, with very complex relationships between cause and effects. There are two sets of conditions conductive to deterioration: intrinsic and extrinsic. Intrinsic conditions are those conditions inherent in a structure, material or its environment that make the component or system susceptible to deterioration. Extrinsic conditions are those external agents or forces that, acting on inherent vulnerabilities, cause deterioration. The most common extrinsic source of masonry deterioration is water penetration (others include heat, light, wind, gravity, chemicals, etc). The degree to which one can mitigate both types of conditions determines the effectiveness of the preservation maintenance strategies.

Considering the practically infinite combinations of materials and conditions and the complexity of their interrelationships, determining probable causes of deterioration is a complicated and difficult process that requires time, patience and a high degree of technical knowledge and skill. Nevertheless, the causes of deterioration can generally be determined through a process of general inspection, thorough investigation and analytical testing of the physical properties of a structure and their response to environmental conditions. Keeping in mind that buildings, along with their immediate surroundings, are in a constant state of flux, maintenance strategies should be based on flexible programs that allow for and adapt to changing conditions and continuing data collection and analysis. The intent is to not only identify and prescribe initial treatment for existing conditions, but to provide for the scheduling of maintenance procedures and the training of personnel to carry them out.

Part of the challenge is to investigate, monitor and correct the conditions; the other is to somehow manage the growing database of assorted information. Substantial benefits would be gained if building owners and facility managers received comprehensive, timely information about their building's current condition and pending maintenance issues. A health maintenance program for buildings could prevent unnecessary deterioration of materials and systems, improve building performance, significantly lower repair costs, and help the owner make accurate budget predictions in advance allowing time for appropriate funding strategies. As and added benefit, condition monitoring and careful documentation provides a wealth of information about how building systems, construction details and maintenance practices perform over time and the repercussions repairs and replacement may have on the rest of the building.

Architects familiar with the building are in a unique position to provide this type of service. Discovering what was successful, what failed, and why, is a learning process not only important for the conservation of the building and the science of preservation, but also as a means to avoid making the same mistake twice.

1. EVALUATION

A. General Inspection

Masonry products and materials, the predominant type found on the Orpheum Theatre, are among the most durable available for construction. Generally, if brickwork is properly designed, detailed and constructed, it is very durable and requires little maintenance. However, many of the other components incorporated in the brickwork, i.e. caps, copings, sills, lintels, sealant joints, terra cotta units etc. will require periodic inspection and repair. Maintenance can be broken down into two general categories: 1) general inspection and maintenance to prolong the life and usefulness of the building; and 2) specific maintenance to identify and correct problems that may develop.

A good, thorough inspection and maintenance program is often inexpensive to initiate and may prove advantageous in extending the life of a building through early detection of maintenance related issues. Regular evaluation would allow the owner or facilities manager to identify small changes that might otherwise go unnoticed over longer time intervals. If caught early enough and dealt with in a timely matter, many minor problems could be resolved with relatively inexpensive repairs. A relatively small time and capital investment could help avoid the high restoration costs associated with ongoing or long-term damage.

As with any building product continuously exposed to the elements, masonry is subject ed to weathering. Acids in the rain, building settlement, freezing and thawing cycles, impact damage and dirt take their toll. Familiarity with the various materials used on a building and an understanding of how they perform over a given time period will help guide maintenance efforts. Typically, mortar joints are serviceable for 35 years or more when properly installed. The masonry units themselves, typically brick or concrete block, may have a serviceable life of 100 years or more. (IMI 7-1) Table 1 lists the estimated life expectancy of assorted building materials under normal weathering conditions.

Material	Use	Estimated Life (years)
Brick Caulking Metal Mortar Plastic	Walls Sealer Coping/ Flashing Walls Flashing	100 or more 8-10 20-40 25 or more 25 or more
Finishes		
Paint Plaster Sealers Silicone Stucco Waxes	Waterproofing Waterproofing Dampproofing Dampproofing Waterproofing Waterproofing	3-5 3-5 1-5 1-5 3-5 1-5

The Brick Institute of America suggests that periodic inspections be performed to deter mine the condition of various materials used on a building. These inspections can be set for any given time interval, however, seasonal inspection has the advantage of allowing observation of the behavior of building materials under varying weather conditions. A mid-summer inspection may yield different information than one conducted in wet or below freezing temperatures. Coordinate inspections with general maintenance cycles.

A general inspection should include the following:

1) Roof- the roof is a structure's primary protection from the weather
    a) roofing materials- determine the type of materials; are there signs of missing warped, broken or otherwise damaged materials; evaluate the

overall condition of roofing materials; is there evidence of ponding; evaluate flashing conditions (attachments, sealant, are moving joints work ing)

b) associated architectural features- evaluate the condition of chimneys, parapets, roof vents, mechanical curbs and units, all other architectural features.

c) roof structure- sloped; flat; is there noticeable sagging, leaking, or stain ing of materials below the roof line; evaluate the condition of roof drains, over flow scuppers, and rain water leaders.

2) Walls and Foundation

a) structure- are walls plumb; are there signs of bowing, bulges, or undula tion; are door and window frames square; are there areas of cracked masonry or other evidence of foundation trouble

b) water damage- identify loose, cracked, deteriorated, missing or otherwise damaged mortar joints or masonry units; is there evidence of surface staining or areas of dampness on exterior walls; are there problems with rising damp; is there noticeable efflorescence or subflorescence

c) wall components- identify missing or damaged materials or components; evaluate soundness of material attachment and general condition of material finishes; are there open joints around door frames, windows, or between dissimilar materials; are areas subject to water penetration sealed appropriately

3) Doors and Windows

a) does the frame fit squarely within the opening

b) condition of frame- is there deterioration, especially around sills, lower rails, or thresholds

c) evaluate condition of glass, glazing, paint finishes and weather stripping

d) is hardware working properly

4) Interior Spaces

a) Finished spaces- look for interior finish damage: cracked or damaged sur face materials such as plaster or stone veneer; water damaged surface finishes - stains, deteriorated or missing plaster; rusted steel anchors; peeling paint; mold or mildew; sagging floors

b) Attic or service spaces- look for signs of deterioration: leaks, especially at the underside of the roof; cracked interior wall surfaces; sagging, deteriorated or otherwise compromised structural elements

In much the same way that a yearly physical helps a doctor track the deterioration of an aging human, continuing observation and monitoring of the physical conditions of a building will help develop a forensic history. Not only does it allow evaluation of developing or ongoing conditions, it also provides a way of documenting the success of previous repairs. Inspection records, including conditions, comments, and where pos sible, photographic documentation, should be kept to help determine future "trouble spots", problems, and needed repairs. Development of an information base specific to a particular building is an invaluable tool for projecting future maintenance costs, guiding continuing maintenance efforts and achieving the ultimate maintenance objective-preservation of the building.

B. Comprehensive Investigation

Information gathered from research and the general inspection will help to establish a schedule and program for a more detailed investigation. Data collection and analytical diagnosis covers a broad spectrum of categories and activities but should include:

1) Historic and Archeological Data:

Historical and archeological data is vital as background information for any program dealing with the causes of deterioration of a structure. Information regarding historic construction methods, technology, materials and detailing, past usage, general conditions, building alterations or additions, etc., provides insight into possible causes of deterioration and is essential in recommending appropriate treatment. For example, shop drawings showing terra cotta installation would be invaluable in determining the location and extent of steel anchorage systems. This information could be used to determine a reasonable strategy for exploring repair or replacement options of terra cotta units.

2) Visual inspection:

A preliminary visual inspection will sometimes allow detection of a self-evident source of water penetration or other surface deterioration problems while not revealing others. Water-related issues are manifested in a number of different ways: efflorescence, spalling, cracking, disintegrating mortar joints, loose bricks, damp walls, interior finish damage, etc. Once one or more of these conditions becomes evident, the direct source of moisture penetration should be determined and action taken to correct both the source of the problem as well as the visible effect.

Water-related problems continue to worsen over time. As the deterioration of building systems and/or their components accelerates, a once manageable situation rapidly advances toward total failure or collapse unless some kind of maintenance intervention is scheduled. In cases where materials are deteriorated, cracked or all together missing, the source of water penetration is obvious. However, there are many cases where multiple sources contribute to the problem and still others where the source may be hidden and determined only through some type of building diagnostics. For a building expressing obvious signs of water-related damage, all possible moisture penetration sources should be investigated and the actual source determined through a process of elimination.

Crack analysis is another relatively easy way to quickly assess the structure using visual clues or symptoms. Size, shape, direction, location, rate of change and overall patterns are all “telltales” that should be recorded. Small cracks, up to 1/64th of an inch are of no concern structurally. Larger cracks on the exterior will allow water penetration, eventually causing structural problems. As the cracks increase in size, more consideration should be given to structural analysis and repair.

Timing is also important. A small crack that has just appeared is of more concern than a large crack that has not moved in fifty years. Cracks that do not move are probably not a structural problem nor are decelerating cracks- those that move more slowly over time, both can be patched once they stop moving. However, if a crack is lengthening or widening rapidly it is important to identify the source of the problem and take cor rective action immediately. Accelerating cracks indicate that the struc tural stability of the building is threatened and that the problem will continue to worsen ultimately resulting in total failure.

There are a number of simple and inexpensive methods and devices, such as two-piece plastic crack meters, available for monitoring crack movement over time. Measurements, made at several locations along the length of the crack, should be taken at regular time intervals over a period of several weeks to determine the amount and direction of movement. This simple technique would be useful in evaluating the vertical crack that runs the entire height of the Orpheum Theatre at the corner of 9th St. and Hawthorne St.

Where terra cotta in concerned, the objective is to locate all defects such as cracked or shattered blocks, rust stained blocks, or units with deposits or residues and relate all to their probable causes. Causes may include structural movement, leaks, failed mortar joints, failed rainwater systems, corroding steel anchors or structural support systems, or inadequate expansion joints. The problems must be resolved before the symptoms can be “treated”.

Architectural investigation can range from a simple one-hour walk-through to a month long or even longer project- and varies from a quick surface examination to a sub-surface investigation which may include laboratory analysis. All projects should begin with the simplest, non-de structive processes and proceed as necessary. A visual overview acquired in a preliminary site visit provides the most limited type of investigation but can resolve many questions quickly and information gained from the preliminary visual inspection will help determine which areas to investi gate further.

3) Non-destructive testing:

The next level of investigation consists of probing beneath the surface using non-destructive testing methods. A number of relatively simple and cost effective techniques provide an effective alternative to destructive tests for determining the condition and material properties of masonry with minimal damage to the historic fabric of the building. These test methods have limited application and generally only provide information on the physical make-up of a system (continuity, location of voids, reinforcement, etc.) These include: borescopes and fiber optics to observe tight or inaccessible spaces; x-rays to penetrate surfaces in order to see various metal fasteners; ultra violet or infra-red imaging to observe differences in materials or finishes. Qualitative condition of masonry can be assessed using a variety of non-destructive tests such as: wave transmission tests, ultrasonic pulse velocity tests, mechanical pulse test, impact-echo test, and surface hardness test. This kind of information is essential for developing a successful condition assessment and designing an appropriate repair strategy.

Metal detectors can be useful in determining the location of internal metal reinforcement, anchors and structural support. Original drawings are helpful in predicting where internal metal anchoring should be. Metal detectors can confirm that they are indeed still there. No reading where an anchor would be expected could indicate a missing anchor or one that has seriously deteriorated. Information gathered in this manner is relatively imprecise but it does provide for a quick assessment without having to physically remove terra cotta units.

Borescope investigation is another cost-effective method of analysis that avoids having to dismantle entire portions of an assembly. A borescope is in effect a bundle of optical fibers with a lighting system and a magnifying eyepiece so designed that the tip can be passed through an existing crack or ½ inch diameter hole and on into an interior cavity. This type of advanced technology, in combination with fiber optic illumination and video cameras, could be particularly useful in determining and recording the structural integrity of the 9th St. balcony. Although severe structural steel deterioration may necessitate the eventual disassembly of the balcony, non-destructive testing can guide repair decisions and save time and money while leaving the assembly intact until work can begin.

Infrared imaging is another non-destructive technique that might be used to determine the general condition of terra cotta units. All materials emit heat, which can be detected and measured in terms of infrared light. Infrared photography, or scanning, can be used to detect sources of heat loss. Broken or loose terra cotta pieces have a less firm attachment to the surrounding firm or attached units and therefore have different thermal properties. Temperature differences become evident on the infrared scan and may serve as a general indicator of internal material deterioration in terra cotta.

The simplest and best technique for surveying and recording the locations of terra cotta problems is to examine each piece by hand using a "sounding technique. The units are struck with a heavy rubber or wooden mallet and will either have a sound "ring" or flat, hollow sound if cracked or loose. On a large building such as the Orpheum Theatre this type of survey should be carried out from the bucket of a crane. Surveys carried out with binoculars from street level or from other buildings are not nearly as effective compared to working from a crane or scaffolding.

Although desirable, a complete survey of all terra cotta units may not be within the project budget, and may also be physically unfeasible. In this case, representative terra cotta units should be selected for close inspection. Units of varying configurations, locations, and conditions should be examined. All types of deterioration observed in the preliminary survey should be represented in the sampling. At some point, it would helpful to develop a schedule of typical units for compiling field data and developing a scope of work plan for future repairs.

4) Destructive testing:

Performing a more in depth evaluation is a time intensive process and often involves the removal of material to allow access to hidden conditions. The owner should be aware that destructive testing is a form of demolition and may damage the historic fabric of the structure. This work should be carried out by a professional only after historical research and surface mapping have been fully accomplished and only after non-destructive testing has failed to produce the necessary information.

Subsurface testing should be restricted to small areas or "windows" at predetermined locations to see suspect conditions beneath the surface. In general, when exploratory holes are being opened up, it is good practice to cut into terra cotta or masonry units that are already damaged in order to get behind and release other units that are in good condition.
Photographs, video and or drawings should record conditions before, during and after evidence is collected. If removed, original fabric should be carefully reinstalled or labeled and stored.

5) Laboratory analysis:

Laboratory analysis plays an objective role in the more intuitive process of architectural investigation. A more thorough scientific approach may be used to accurately profile and compare samples of materials, i.e. paint, mortar, brick, etc., through elemental analysis. Although it is not necessary to perform analysis at this level for every material, pertinent information regarding mortar, brick, and terra cotta properties should be quantified and recorded. Once established, the results can be referenced for future repair work.

Although time consuming, if done ahead of time, an in depth condition survey will provide information that will accurately define the scope of work necessary to resolve various issues and help develop a more accurate and realistic set of bidding documents. If time does not allow for a detailed conditions survey before the job goes out for bid, recommendations for work to be done will most likely be based solely on interpretation of visual clues and may or may not accurately reflect the nature or extent of the problems. In this case, the contractor may have to conduct an in-depth investigation once on board which, given the multitude of unknowns, could feasibly change the scope of the work and the nature of the project in general considerably, leaving the owner vulnerable to the change order process.

Knowing in advance the exact nature and extent of the problems would help to prioritize work that needs to be done. If necessary, work could be phased in over an extended period of time. Although the overall cost of running a number of smaller projects would probably exceed the cost of doing everything at one time, there may be an advantage to breaking the budget into smaller "bite sized" pieces. Even though there is some inherent inefficiency in this approach, it could be an effective strategy where long delivery times and/or seasonal constraints effect the construction schedule or where a smaller project better fits the annual maintenance budget. It could also buy time during which additional funding could be secured.

2. DOCUMENTATION

A. Surface mapping. The first step in a thorough, systematic investigation is the ex amination of all surfaces. Surface investigation is sometimes called "surface mapping" because it entails an in depth look at the exterior, and/or interior, surface conditions which are then graphically recorded in a set of document drawings, photographs, and/or written narrative. The complexity of the project will dictate the complexity of the report. The purpose of surface mapping is four fold: to observe every visible detail of design and construction; to develop questions related to evidence and possible alterations; to identify patterns or sets of patterns and note structural and/or environmental problems; and to help develop plans for any further investigation.

B. Photographic documentation. Photographic documentation, used alone or con junction with surface mapping techniques, provides an additional benefit in that evidence collected serves as a documented benchmark for existing conditions and helps put any subsequent changes in the condition of the building, including new or continuing deterioration, in perspective. Changes can be monitored and compared specifically as well as in terms of the overall physical condition of the building as a whole.

C. Inventory of specific pieces and related work. This strategy, especially when applied to terra cotta elements, could be very useful in predicting the life span of certain components of a building. Creating a complete inventory of all terra cotta units, including their current condition and history of repairs made, would assist in keeping track of work done, work that needs to be done immanently, and work that may need to be done at some future date. From an architectural perspective, this kind of expanded history of specific repairs would be an invaluable tool for evaluating the effectiveness and timeliness of past repairs and an important guide for estimating the type of repairs and timing of work to be done in the future. From an owner's perspective, advanced information allows for budget preparation ahead of time.

D. History of work done. Whether or not all work being planned is actually carried out, the architectural investigative report will always be of value to future researchers or owners of the building. Documentation is especially important when working on a historic building where preservation and restoration guide lines are more precise. Ultimately, the results of investigations, a record or inventory of current conditions or problems, records of past repairs and treatments, conclusions and recommendations for current and future action should all be consolidated in some kind of accessible format available to those planning treat ment currently or at some future date. Maintaining and preserving a building is an evolving process and the permanent record should make allowances for new insight as information becomes available.

3. RESTORATION AND REPAIR

The growing body of conclusive evidence may, in turn, lead to re-examination, more historical research, and the advice of specialized consultants. At some point however, treatment or repair generally follows based on the collective, educated conclusions of the entire professional team. Once the source of deterioration is determined, measures can be taken to effectively remedy the problem and its effects on brickwork or other materials.

A. Stabilization

Pending the outcome of the building survey, appropriate steps should be taken to stabilize, protect and secure the structure against ongoing and potential property damage or personal injury. Stabilization is not to be confused with repair. Stabilization is an attempt to arrest deterioration whereas repair refers to a process or methodology that eliminates the source and effect of previous damage.

Of primary concern is the elimination of life-safety or personal injury hazards such as: broken steps; loose handrails; badly bowed or falling plaster; loose architectural elements that could become dislodged and fall from the building; blatant health hazards such as friable asbestos and airborne lead dust from chipped paint. Abatement, temporary shoring or temporary repairs may be required to bring the structure into compliance with various health and safety codes.

Structural work is also high on the list of priorities and should be given full and careful consideration for the following reasons: it represents a relatively major cost; it requires that problem areas be opened up or dismantled to allow access to underlying structural elements; it often affects more than just the immediate area of work; and, it is time consuming. Due to their high level of complexity, structural modifications usually require an all-or-nothing approach, since work is difficult to accomplish in phases. One advantage is that repairs could mitigate certain life-safety issues.

Once personal safety is assured measures should be taken to secure against the loss or damage of historic elements to vandalism, theft, and natural deterioration processes. For example, loose building parts should be carefully removed or temporarily secured until appropriate repairs can be made. Where mechanical fastening is not practical, barriers or netting that “catch” or deflect falling debris might be worth consideration.

Care should be taken that temporary repairs or stabilization methods do not cause more damage over the long term than what it serves to prevent in the short term. If the temporary repair is not cost effective, or could cause additional damage, a proper repair should be undertaken immediately. For example, a leaking roof presents the potential for continuing and increasingly serious damage due to the effects of long-term water penetration. This condition can be temporarily stabilized with removable sealants, inexpensive metal flashing, or in some cases, something as simple as a canvass cover. Bituminous compounds, on the other hand, may stop a leak temporarily but will inevitably exacerbate the deterioration of terra cotta coping thus making a bad situation worse.

Occasionally decisions will have to be made whether to defer repairs and rely solely on stabilization of an affected area, perhaps until budget or scheduling issues can be resolved, or whether to proceed with complete and proper repairs. Stabilization, although not an ideal solution, is a better solution than doing nothing at all. Although some expenditure on the part of the owner is usually required, the cost of stabilization will probably be reasonable when compared to the additional expenses, associated with continued deterioration and possible loss of the material or affected systems, which could be incurred should the conditions be ignored.

B. Repair Methods

No one solution will remedy similar problems in a building. Repair methods that effectively suit the particular needs of each location should be evaluated and selected when a problem occurs. When deciding the nature and extent of repairs, there are a few general rules of thumb to remember:

- Consider maintenance cycles and cost-effectiveness when making fundamental decisions for repair or replacement. For example, replacing terra cotta water table base units with stone may be a better long-term solution at this particular location. Terra cotta is more sensitive to the effects of deicing salts and water penetration and may require repair or replace ment ooner than one. Although installation costs may be similar, mate al costs favor stone in both the long and short term.

- Anticipate and avoid unnecessary future costs. Performing routine maintenance and repairs may prevent costly restoration repairs in the future. For example, unless all sources of water penetration are resolved, repairing or replacing water-damaged terra cotta cornice units is an exercise in futility.

- Match life spans within a system when replacing materials. For example, do not re-anchor masonry that could last 100 years with steel fasteners that last fifteen.

1) Masonry
<u>Sealant Replacement</u>

Missing or deteriorated caulking and sealants in contact areas between brickwork and other materials, i.e. window and door frames, expansion joints, flashing, threshold conditions, etc. may be a source of moisture penetration. The sealant joints in these areas should be inspected. If the sealant is missing, a full bead of high-quality, permanently elastic sealant compound should be placed in the open joint. If a sealant material was installed, but has torn, deteriorated or lost elasticity, it should be carefully cut out. The opening must be clean of all old sealant material. A new sealant should be placed in the clean joint. (See spec section)

The (4) historic exit doors in the southeast court provide a good example of an area where this type of minimal repair, done early on, could have saved the costly masonry repairs currently required. Water penetration at the joint between the wall and threshold has caused severe deterioration of the brick masonry and mortar joints, a condition that has worsened considerably over the last few years. At this point, 25-30 sf of masonry needs to be repaired/replaced at each door. (see detail 73 &74/4-9)

Mortar joints

Mortar joints in a historic building are often called a wall's "first line of defense." When visual inspection reveals that the mortar joints are open, cracking, missing or otherwise deteriorated, restoration is necessary to help maintain the integrity of the wall systems and historic structure.

There are three common terms, often used interchangeably in the United States and Canada, to describe the process of restoring older masonry joints. The Preservation Briefs published by the U.S. Department of the Interior National Park Service use the terms pointing and repointing to refer to the process of cutting out and removing deteriorated mortar joints in masonry walls to a uniform depth and replacing those joints with new mortar. Tuckpointing, a common term used by the International Masonry Institute, references the same technique. However, in some areas this term refers to a process in which plastic mortar is placed in joints without first removing damaged mortar. This process, more correctly referred to as surface grouting, is sometimes suggested as an alternative to repointing. To be effective, the grout must extend slightly onto the face of the masonry units thus widening the joint visually. Any change in joint appearance can alter the aesthetic character and therefore threaten the historic integrity of the structure. "Surface grouting cannot substitute for the more extensive work of repointing , and it is not a recommended treatment for historic masonry." (PB-2)

Repointing is an effective way of decreasing water entry into masonry. When properly done, repointing provides a strong, waterproof mortar joint that matches the appearance of the original mortar joints and helps extend the life of the building by restoring both visual and physical integrity of the masonry. "A good repointing job is meant to last, at least 30 years, and preferably 50-100 years." (PB-2) However, it is labor-intensive process and therefore expensive. (See spec section 04520)

Accurately determining the exact scope of work is not always easy. Many areas of a building are not easily accessible and visual assessments, often made from a distance, are not entirely accurate. Certain assumptions may have to be made based on the evidence at hand. For example, comparing original drawings to existing conditions, i.e. holes, scars, patches, nails, shadow outlines of missing features formed by paint, plaster, wear, weathering, dirt etc., can help architects and engineers determine whether details, as originally designed, or subsequent modifications may be contributing to the current conditions. Missing or damaged interior plaster may provide information as to the source and extent of water penetration and act as an indicator for the extent of deterioration to be anticipated in nearby areas that are not readily viewed.

There must be adequate time for evaluation of the building and investigation into the cause of the problems. Areas with obvious deterioration can be clearly defined on the bid documents, however, water related damages will often have a far-reaching effect on areas not always readily visible. Thorough investigation will often require removal of masonry units to determine the extent of damage and deterioration. When a full condition survey is not possible, the owner should expect some changes based upon closer inspection.

A number of considerations can help manage the scope of work and unit cost. For example, when the results of forensic analysis, or more frequently budget constraints, dictate that only a portion of the mortar joints on a building are to be repointed, criteria such as the particular depth of the eroded joint can be established ahead of time. If the mortar joints show evidence of small hairline cracks, surface grouting or pointing may be an effective means of sealing them. Consideration should also be given to the method of mortar removal. Power tools, such as saws and grinders are faster than hammers and chisels but they may damage the masonry units and surrounding mortar. Additionally, if an historic building is being restored, mechanical tools may not be allowed, or if they are, only if special permits are obtained.

Another aspect of the repointing process that benefits from a more formal analysis is the physical quality of the mortar itself. Preliminary research is necessary to ensure that the proposed repointing work is both physically and visually appropriate to the building. There are many factors to consider when selecting an appropriate replacement mortar: the age of the building, the relative strength and composition of original mortar, vapor permeability, and the profile of the tooled joint. Commercially available mortars should generally not be used for maintenance repairs. The potential incompatibility with historic materials could cause significant consequential damage that exceeds that of the initial repair.

"In creating a repointing mortar that is compatible with the masonry units, the objective is to achieve one that matches the historic mortar as closely as possible, so that the new material can coexist with the old in a sympathetic, supportive and, if necessary, sacrificial capacity. The exact physical and chemical properties of the historic mortar are not of major significance as long as the new mortar conforms to the following criteria:" (PB-2)

- The new mortar must match the historic mortar in color, texture and tooling.

- The sand must match the sand in historic mortar. There are a number of laboratory procedures available that give insight into the chemical composition of existing mortar. The most useful information that comes from laboratory analysis is the identification of sand gradation and color. Sand is the largest ingredient by volume and is therefore one of the most critical components in the mortar mix. Determination of the sand characteristics allows color and texture of the original mortar to be matched with a higher degree of accuracy.

- The new mortar must have greater vapor permeability and be softer (measured in compressive strength) than the masonry units. Stresses within a wall caused by expansion, contraction, moisture migration, or settlement must be accommodated in some manner. Stress relief should preferably be provided by the mortar rather than by the masonry units. A mortar stronger in compressive strength than the masonry units will transfer the stresses to masonry unit, resulting in permanent damage to the masonry such as cracking and spalling. It is easier to repair a masonry joint than it is to repair a damaged masonry unit.

  Permeability is also critical. "Historically, mortar acted as a bedding material- not unlike an expansion joint- rather than a "glue" for the masonry units, and moisture was able to migrate through the mortar joints rather than the masonry units. When moisture evaporates from the masonry it deposits any soluble salts either on the surface as efflorescence or below the surface as subflorescence. While surface deposits are relatively harmless, salt crystallization within a unit creates pressure that can lead to spalling or delamination. If moisture can not migrate out of the wall and evaporate from the mortar joints, the result will be damage to brick masonry units.

- The new mortar must be as vapor permeable and as soft or softer (measured in compressive strength) than the historic mortar. Older mortars are weaker than modern portland cement mortars and have less compressive strength. Stronger repointing mortars deform less under load than the historic mortars.

Final joint tooling should match the original profile. If mortar is not matched closely to the original or if installed incorrectly, the mismatch is obvious and the overall visual effect is compromised to the point of distraction. Shortcuts and poor craftsmanship diminish the historic character of the building, although functionally sound, the altered aesthetic value is unacceptable and will require future repointing sooner than if the work had been done correctly. The repointing job on the upper portion of the wall on the Hawthorne elevation, performed during the 1992 renovation, illustrates this point. Joints in this area were not tooled to match the original construction and should be replaced, an unfortunate waste of time and resources. (See)

It would be a mistake to assume that repointing alone will solve deficiencies resulting from other or additional problems. "The root cause of the deterioration- leaking roofs or gutters, differential settlement of the building, capillary action causing rising damp, or extreme weather exposure- should always be dealt with prior to beginning work. Without appropriate repairs to eliminate the source of the problem, mortar deterioration will continue and any repointing will have been a waste of time and money." (PB-2)

Good repointing practices help guarantee the longevity of the mortar joint, the wall system and ultimately the historic structure itself. Although careful maintenance will help preserve the freshly repointed mortar joints, it is important to remember that mortar joints are meant to be sacrificial and will require repointing some time in the future. Considering that the historic mortar joints proved durable for many years, it is reasonable to assume that careful repointing should have an equally long life, ultimately contributing to the preservation of the entire building.

Masonry Units

The composition and material qualities of historic brick vary as much as much if not more than mortar. Generally, historic brick tends to be softer and more porous compared to modern brick. Many were made from clay mixes which were far from ideal but were used simply because they were readily available. The mix of clay and sand, as well as the processes used for weathering, tempering, coloring, drying, firing, and cooling, all effect the quality and appearance of a brick and impart a distinctive character and charm not seen in commercially manufactured brick today.

As stated earlier, when properly designed, detailed and constructed, brickwork is very durable and requires little maintenance. However, brick damage can result from the effects of moisture penetration, mechanical impact, chemical attack, etc. The most severe damage is often water-related and occurs when brickwork has been saturated with water for prolonged periods. A second category of deterioration is associated with poor or misguided attempts at maintenance and restoration. The unique character of historic brick and mortar is often incompatible with modern formulations. If not carefully researched, modern interventions can cause secondary problems that are more serious than the initial repair.

Prolonged water saturation poses a serious threat to a masonry system. Over time, mortar is eroded or washed away, brickwork loses its cohesion and subsequently starts to shift or fall. Ties securing brick veneer may break or corrode entirely leaving the remaining brick unstable and vulnerable to collapse. Water saturated bricks also suffer from freeze-thaw cycles, the result- shattered units or spalled surfaces. As more widespread deterioration occurs, ice develops between the wythes, causing buckling or expulsion of the outer wythe. The south wall of the Pantages Theatre's main auditorium provides a good example of this kind of advanced water damage.

Another obvious sign of water saturation is the formation of water-soluble salts at (efflorescence) or just below (subflorescence) the brick surface. These crystalline deposits may expand to many times their initial volumes when they take up water from the surrounding environment. This expansion can exert enormous pressures on the walls of the small voids in which they are concentrated. Repeated cycles of hydration and dehydration of salt crystals in the surface pores leads to crumbling and delamination of the brick surface. This kind of damage is often associated with prolonged saturation from leaking roofs, gutters or rain water pipes, exposure to deicing salts or rising damp at the base course.

There is a significant amount of efflorescence visible on the interior wall surface just behind the cornice on the 9th St. facade that can probably be attributed to a compromised roofing detail that we believe has since been repaired. Although the major source of water penetration may have been resolved, the effects of prolonged water saturation still pose a serious threat to the masonry wall system. Eroded mortar and serious corrosion of the structural steel supporting the cornice contribute to ongoing deterioration. Specifically, rust-jacking of back to back angles continues to transfer compressive stresses to the masonry wall and causing further damage to adjacent brickwork. In its current condition, this particular area presents a potential life safety hazard that needs to be fully investigated in order to determine the structural integrity of the upper wall and cornice support system.

This type of compounding problem is again evident at the parapets and cornices of the corner towers. Initially, water may have penetrated the top of the parapet wall at the coping. Although an attempt to alleviate this problem through use of metal flashing resolved one aspect of the problem, the deteriorated brick and cracked mortar below were not repaired and still allow a significant amount of moisture to enter the wall system. Consequently, the absorbed moisture seems to be threatening the structural integrity of the terra cotta cornice, particularly at the corners where visual cracks in the masonry directly above are observed. Almost every corner terra cotta unit is severely cracked and many show signs of displacement. Not surprisingly, the brickwork with the most severe deterioration corresponds to the highest level of damage seen in the terra cotta units. This situation is currently being viewed as a potential life safety concern and the repairs are expected to be costly.

Regardless of the source, once the various forms of damage or deterioration described above have taken place, replacement of the affected units may be necessary. If repairs are not made, there is tremendous risk of future damage to the effected unit and surrounding materials. Depending on how long maintenance is deferred, as deterioration spreads to other areas or components within a system, escalating damage will obviously have a much higher cost associated with repairs.

2) Terra Cotta

Terra cotta reached the height of its popularity in the United States between the late nineteenth century and the 1930's. It not only provided a modular, varied, and relatively inexpensive approach to wall and floor construction, but it offered seemingly unlimited opportunities for sculptural and ornamental detailing. Although terra cotta fell out of favor with changing trends in architectural styles, rising production costs and development of reinforced concrete, it is still one of the most prevalent masonry building materials found in the urban environment today.

Materials and Manufacture

The term terra cotta generally refers to ornamental or cladding materials manufactured from damp, fully plastic clays that are hand molded or cast into hollow blocks, heavily glazed, then fired at high temperatures. The resulting clay masonry units are generally larger, harder and more compact than brick. Terra cotta units are typically open at the back, with internal stiffeners or webbing separating the unit into compartments. The webbing substantially strengthens the load-bearing capacity of the hollow terra cotta block without greatly increasing its weight. Historically there are four types or categories of terra cotta used in building construction across the country: 1) brownstone, 2) fireproof construction, 3) ceramic veneer, and 4) glazed architectural.

Architectural terra cotta, although similar to clay brick and clay tile, is distinguished primarily as a decorative building component. By 1922, a large color palette was available for glazed terra cotta including a wide range of colored imitation stone finishes, like that seen on the Orpheum Theatre, and a handful of metallic finishes that looked like gilding.

The manufacturing process is extremely complex and relies heavily on the skills of experienced artisans. Clay is excavated, weathered, mixed, and refined over an extended period of time before it is pressed into plaster molds or extruded. Clay properties naturally change over time and clay excavated from a similar location many years apart will have somewhat different properties. Subtle material differences may result in a very different product even when using the exact same mold. This point should be considered when deciding whether certain work should be phased in over long periods of time.

The clay model and companion plaster mold are purposely created one-twelfth oversize to allow for the shrinkage which inevitably occurs during the subsequent drying and firing processes. Exterior walls are 1-1 ½ inches thick and are strengthened and stabilized by internal webbing. The plaster mold draws moisture from the packed clay, which then shrinks, thus releasing itself from the form after about three days at room temperature. The surface is then finished with hand tools and set aside for a longer, temperature controlled drying period that could last anywhere from a few days to several months. Dried units are then coated with slips and fired. An additional glaze might be applied over a slip singly or in combination with great care given to the "fit" of the glaze to the terra cotta body. This process explains the long lead time (approximately 120 days after final approval of shop drawings) required for ordering replacement units.

Earlier in the century there were hundreds of manufacturing plants operating in Europe. In the United States more than a dozen were producing terra cotta here in the Midwest. After the 1920's, none of the central plants remained in business and today only a handful of businesses on either coast carry on the tradition. For this reason, terra cotta has been, until fairly recently, somewhat difficult to procure.

Defects and Common Deterioration Problems in Terra Cotta Building Systems

Terra cotta has many inherent advantages. When detailed and installed correctly, it has a long proven resistance to extreme weather conditions and pollution. It provided for crisp, intricate, repetitive modeling of architectural details without loss of refinement. Compared to stone, it was easier to handle, quicker to install, and more affordable to use. Thought to be fireproof and waterproof, it was readily adaptable to structures of almost any height and location. Historically, the cost of molding the clay, glazing and firing the blocks, when compared to stone, represented considerable savings especially when casting modular or repetitive units. Maintenance was easy; the fired and glazed surface never needed paint and periodic cleaning restored its original appearance.

Over time, many of the phenomenal claims of the early proponents have proven true. There are many examples attesting to the permanence and durability of terra cotta. However, an initial poor understanding of the nature and limitations of the material is becoming more apparent. Today, the deterioration of terra cotta work is perhaps one of the most complicated forms of deterioration of building materials and systems confronting restoration specialists. No one case of deterioration is ever identical to another owing to the infinite number of variations with environmental conditions, detailing and the physical properties of the material itself. Generally, material failure can most commonly be attributed to water related problems. Other causes may include faulty original craftsmanship, stress-related deterioration, alteration damage, or inappropriate repairs.

Water Penetration and Subsequent Corrosion of Metal Anchors or Structural Supports. As with most building rehabilitation problems, water is a principal source of deterioration in glazed architectural terra cotta and the root of deterioration can often be traced back to misapplication of the material. Historically, glazed architectural terra cotta was viewed as a highly waterproof system therefore not requiring flashing, weep holes or drips. This supposition has proven untrue as serious water-related failures became evident early on in the life of many terra cotta clad or detailed buildings. Terra cotta systems are highly susceptible to such complex water-related deterioration problems as glaze cracking, glaze spalling and material loss, missing masonry units and deteriorated metal anchoring.

- Crazing, or the formation of small random cracks in the glaze is a common form of water-related deterioration in glazed architectural terra cotta. When the new terra cotta unit leaves the kiln after firing it has, through the process of drying, shrunken to its smallest possible size. Over the course of many years, the unit will expand as it continues to absorb moisture from the air. Unit expansion causes the glaze to go into tension because it has less capacity for expansion than the porous clay body, it no longer "fits" the expanding unit onto which it was originally fired. If the strength of the glaze is exceeded, it will crack or craze. This may occur as a normal process in the aging of the material and unless the cracks visibly extend into the porous tile body of the unit, crazing should not be regarded as highly serious material failure. It does, however, tend to increase the water absorption capability of the unit. Units that appear to have significantly more crazing than adjacent units should be monitored for changes in appearance or severity of the condition, in which case more aggressive treatment may be required to prevent further deterioration of the unit.

- Spalling, the partial loss of surface material, is commonly a result of water trapped within the masonry system itself. Poor water detailing in the original design, insufficient maintenance, rising damp or a leaking roof can all lead to water entering and becoming trapped within the system. In most cases, trapped water tends to migrate outward through masonry walls where it eventually evaporates. In glazed terra cotta, the relatively impervious glaze on the surface, which acts as a water barrier, blocks water movement. The water stops at the glaze until it builds up sufficient pressure, particularly in conditions of widely fluctuating temperature, to pop off sections of the glaze or, in the worst case scenario, portions of the terra cotta unit itself.

Material spalling is a particularly severe situation. Not only is the visual integrity of the detailing impaired, but a large area of the porous underbody, webbing and metal anchoring is exposed to the destructive effects of continuing water penetration and further deterioration. Furthermore, spalling may be symptomatic of deterioration of the internal metal anchoring system that holds the unit in place. For these reasons, both glaze and material spalling must be dealt with as soon as possible.

- Missing Units present a serious situation. Gaps can increase the structural load on remaining pieces and permit water to easily enter the system. Exposed, projecting or freestanding glazed architectural details (balusters, urns, parapets, etc.) are particularly susceptible to extensive loss of material. These elements are subject to the most severe effects of water- and temperature-related deterioration in direct proportion to the extent of their exposure. Replacing missing units should be a high priority work item

Terra cotta cladding and veneer rely on an extensive and complex system of metal anchors and ties to suspend it from structural steelwork or tie it back to a steel superstructure or masonry backup wall. Other terra cotta units such as columns and balusters may have steel armatures or vertical rods passing through them to keep them aligned and in position. Should water enter the hollow terra cotta unit, corrosion of the steel will begin along with the accompanying expansion of rusted components. Rust takes up many times the volume of the original metal (up to ten times its original cross section) and if the metal was tightly set, the force exerted by expanding corrosion products is often sufficient to shatter the adjacent or surrounding blocks. This phenomenon is known as “rust jacking”. Deterioration creates a “domino-like” breakdown of the whole system: glazed units, mortar, metal anchors, masonry and steel backup. In no other masonry system is material failure potentially so complicated.

Terra cotta work associated with drainage details or rainwater pipes should be fully investigated. Pipes were often made of cast iron that corroded and often split when water froze in them. The resultant leaks could cause severe damage that might become critical before the problems were spotted and investigated. Balconies and parapet details raise similar concerns where water can be easily trapped or where drains are undersized or easily blocked. Masses of ice or dammed up water could feasibly tear apart the terra cotta or lead to corrosion of hidden steelwork which in turn produces the same end result.

Corrosion of hidden steelwork can be one of the most difficult faults to diagnose. Often the damage must be severe and irreparable before noticeable signs appear at the surface. There are however, some good general indicators. Rust streaks and structural cracks through individual units or small groups of units, especially those associated with an outward bursting or displacement of the block, are often found to be associated with the formation of thick layers of rust on steelwork immediately behind the worst damaged areas. Hidden metal work can be located using a portable metal detector. Other equipment, used to detect the weak electrical fields existing around corroding metals, can help pinpoint areas of major corrosion and limit or focus the extent of work that needs to be opened up.

Deterioration and failure of the steel anchoring system is often severe and unfortunately fairly common especially in areas where parapets or coping have been poorly maintained. Where water has entered the system, some deterioration has more than likely taken place. Partial deterioration results in staining and material spalling. Total deterioration and the lack of any functioning anchoring system may result in the loosening or displacement of units themselves thus threatening the architectural and structural integrity of the building. The problem can be especially dangerous if corrosion takes place in hidden steelwork that supports large overhanging cornices that may be 100 feet or more above the sidewalk.

At the Orpheum Theatre, the terra cotta cornice along the 9th St. facade has many open joints above and between units, some units are obviously displaced, and there is evidence of prolonged water penetration from the brickwork and coping above. Steel support angles flush with the interior face of the masonry wall, and presumably carrying the cornice, are severely corroded and delaminated steel can be pulled off by hand. Further investigation will need to be carried out to determine the severity and full extent of the deterioration. Similar water-related deterioration is expected at the tower cornices, balcony and lintel over the recessed vestibule.

Manufacturing-Related Defects. A series of problems seen in terra cotta units have their origins in the manufacturing process. Normally these units are rejected before they leave the plant but occasionally flawed units may have slipped by and found their way into a building. Exposure of faulty units to extreme weather conditions or water penetration leads to an almost inevitable failure. Problems are related to five general categories: underburning, packing faults or voids, glaze problems, warping or cracking, and dimensional tolerances.

Overloading. A large group of failures can be related to the cracking of the rather brittle, comparatively thin-walled terra cotta units under concentrated loads. One particularly common instance of this type of failure occurs when the terra cotta cladding becomes load-bearing as a result of differential movement between cladding and the structural framework of the building. In this case, projecting string courses, band courses or intermediate cornices will have their hollow rear sections crushed between the cladding of walls immediately above and below the projecting details. Cracking may occur along the center of the front face of the projecting units or along the top or bottom just at, or behind the face.

Severe overloading can be caused by the lack of provision of expansion joints. Many older buildings have little or no provisions for normal material and building movement in their original design. Structural movement in walls due to foundation settlement and rotation, thermal and moisture related movements, and expansion of the terra cotta units themselves, all lead to overstressing and cracking of terra cotta units if the terra cotta is restrained. Accumulating stresses will lead to the formation of cracks running through many units and eventual catastrophic failure. In effect, the building creates it's own expansion joint. This sort of deterioration, in turn, permits significant water entry into the system and the level of deterioration and damage is consequently amplified.

Unsuitable Mortars. Mortar is the key to the survival or failure of any masonry system. This is particularly true with glazed architectural terra cotta. In recognition of the fragile nature of the system, the need for insuring a relatively dry internal environ-ment is critical and as stated earlier, sound mortar is the first line of defense. Mortar inspection and repair is considered a maintenance "must", an obligation of which the importance cannot be understated.

Mortars are used to both bed and set the terra cotta units and to fill the voids in the back of the hollow units. These mortars tend to cause problems for two reasons. The joints, usually about ¼ inch wide, are filled with a dense, hard and brittle mortar. Joint profiles are usually very nearly flush or slightly concave. If the units expand against the mortar in the joints the hard mortar tends to crush the edges of the units. On the other hand, if the units contract they tend to pull away from the mortar and open up a crack. Once the gaps open, water penetrates through the cracks and is trapped, along with dissolved salts, behind the mortar. Trapped water leads to number of problems as discussed below.

Although deteriorated mortar is a major source of glazed terra cotta failure, deterioration of materials or systems adjoining the terra cotta (flashing, capping, roofing, and caulking around windows and doors) also bears significant responsibility. When adjoining materials fail, largely as a result of insufficient maintenance, water-related deterioration results. For instance, it is not unusual to find terra cotta spalling in close proximity to a window or doorway where caulking has deteriorated.

Erosion and Abrasion. The integrity of the glaze/slip combination is of great importance to the conservation of the terra cotta as a whole. Erosion of the glaze may result from continuous exposure to wind, dust and other particulates in non-protected turbulent areas in much the same manner as surfaces subjected to sandblasting techniques. Once damaged, the surface absorbs water more readily and deterioration is likely to accelerate.

Alteration Damage and Inappropriate Repairs. Alterations will inevitably be made to a structure throughout the course of its long life. Fasteners and anchors for signs, fire escapes, electrical service devices and a variety of other miscellaneous items are fastened to the building frame through bored holes, or are occasionally cut into or smashed through the glazed terra cotta surface. Every time this surface is perforated there is a risk of water penetration to the body behind or into the wall assembly as a whole and these holes become a significant source of water-related damage. Over time, residual attachments themselves begin to corrode and shatter the surrounding terra cotta.

Terra cotta will often be found to have been repaired or patched with totally unsuitable hard Portland cement based mortars, roofing tar, caulking compounds or galvanized steel flashing. Improper anchoring or bonding of repair work and visual incompatibility of repairs themselves will ultimately become rehabilitation problems. These repairs are often difficult to remove but should be carefully examined to ensure that they are not causing more damage to the terra cotta. The bituminous compound used to seal joints and patch spalled terra cotta cornice units on the Orpheum Theatre provides a good example of how an inappropriate repair can actually make matters worse by accelerating deterioration of the terra cotta units.

Restoration, Repair and Maintenance

Determining the source and level of deterioration of terra cotta is a challenging task in that the outward signs of decay do not always indicate the more serious problems within. It is therefore imperative that the repair and replacement of deteriorated glazed terra cotta not be undertaken unless all causes of the deterioration have been determined and completely resolved. As previously mentioned, the greatest single cause of problems in terra cotta work is the presence of water in or behind the terra cotta and subsequent corrosion of hidden masonry anchorage and structural steel. It follows that one of the most important conservation methods is to prevent water from getting into the terra cotta via joints, through failing porous or permeable surfaces, via masonry backup, or from leaking drains and rainwater gutters. Repointing, caulking, flashing, repairing damaged brick masonry, etc. are therefore also high priority concerns.

Where stress-related or structural problems have caused the deterioration of glazed terra cotta, a structural engineer should be brought on board to mitigate the problems. This may include the installation of relieving joints, shelf angles or flexible joints. Stress-related and structural deterioration, like water-related deterioration, must be stopped before effective repair or replacement efforts are initiated.

Improper repairs that blocked weep holes or sealed joints or surfaces in the terra cotta envelope that were originally designed to act as vents or drains should be rectified. Outward migration of water vapor normally occurs through the mortar joints in glazed architectural terra cotta systems. Because mortar joints were somewhat permeable, moisture within the hollow unit could escape through the joints rather than being forced to travel through the face of the terra cotta unit itself where it could cause severe damage if trapped and frozen.

Where original design details for conducting water have been insufficient, installation of new flashing or weepholes should be factored into the repair work to be done. At the Orpheum Theatre, one particular detail may be the primary contributing source for the severe water-related deterioration seen at the balcony along 9th Street. Although water infiltration has caused damage along the entire length of the balcony, it appears to be most severe at both brick masonry end piers. Deeply recessed ledges behind the end piers provide a relatively flat surface where snow and ice tend to accumulate. At some point, a concrete wash was provided to help direct water off the ledge. However, repeated freeze-thaw cycles have opened up the joints along the edges of the ledge providing an avenue for water penetration into the adjacent brick masonry pier and terra cotta soffit below. Installing metal flashing and counterflashing, a reasonably simple and inexpensive repair, around the back of the pier and top of the ledge should keep water out of the system.

Once all sources of water penetration have been resolved, terra cotta repairs can begin and will probably include most if not all of the following:

- Reattachment of units to their backup masonry or to the structural framework of the building
- Repair of spalled-off fragments and areas of slip and/or glaze loss
- Repair of cracked terra cotta units
- Removal of corroded steel reinforcement and secondary supports and subsequent replacement with new stainless steel or non-corroding metals. Where sulfur has been used for setting units, this too should be removed to avoid deposits of expansive sulfates
- Repair mortar for rebedding and repointing
- Replace damaged or missing units with new terra cotta to match existing or with approved substitute materials

Reattachment and Repair. Cracked and/or detached terra cotta units are normally repaired and reattached using threaded stainless steel rods and moisture-insensitive epoxy resins. Epoxy resins should also be resistant to ultraviolet radiation that can cause yellowing or other color changes along with other forms of degradation. Cracked units that can be removed from the wall can simply be stuck together again with resins and pins. If the units are to be repaired in place, the resin can be injected into cracks using a hypodermic needle. In all cases where epoxy or synthetic resins are used for repairs, care must be taken to protect the terra cotta from spills. Once cured, resins are difficult if not impossible to remove.

Where units are loose or detached but can not be easily removed without causing further damage, holes can be drilled through the unit using diamond tipped coring bits and then stainless steel rods are inserted and set in epoxy resin. Recessed or countersunk nuts can be threaded onto the rods to secure the blocks and then concealed with a color matched terra cotta composite patching mix. Pins or rods for attachment or reinforcement are also available in the form of threaded nylon or Teflon rods. Lightweight grouts may be injected under pressure to reattach terra cotta units where the backup mortar has failed.

Surface Coating. In cases where there have been losses of very thin layers of glaze and slip finishes or where craquelure or crazing has destroyed the integrity of the glaze, excellent results have been achieved by applying breathable masonry coatings based on silicates. The glaze on new unexposed terra cotta, although water resistant, is not completely waterproof. Vapor permeable coatings are invaluable in restoring weather-resistant qualities back to units that have had their permeable core exposed. Manufacturers warrantee should be checked, but generally these materials are effective for five to seven years and can be reapplied. Coating failures are usually associated with problems caused by moisture being trapped behind a coating that is not sufficiently vapor-permeable.

Glazed terra cotta units also benefit from being washed down with appropriate cleaning solutions on a regular basis, much as you would windows. Such regular cleaning prevents the build up of potentially harmful deposits, such as bird droppings, pollutants and salts, thus ensuring the extended durability of the critical outer surface coating of the terra cotta. A major asset, and much advertised selling point, of glazed architectural terra cotta is that it was designed to be cleaned cheaply and easily.

Surface Repairs. Where small portions of material have spalled, where units are removed from close scrutiny (i.e. cornices, entablature detailing, upper story units, etc.), or where visual or cosmetic considerations are of minor concern, minor material spalling should be treated with vapor permeable coatings in a manner similar to glaze spalling. Units that are easily observed, or where visual integrity is important, should be considered for plastic repair or replacement.

Plastic Repairs. The term "plastic repair" is used to describe the process which use composites of mortar, special aggregates, non-fading pigments, and small quantities of synthetic resins to make workable patching compounds which will harden as they cure. Where fragments of terra cotta have spalled off, these patching compounds can be used to restore the surface, molding profiles, and other important details. Doubling the safety factor by providing combinations of epoxy resin-based composites with stainless steel reinforcement is often preferred to ensure that repairs are securely bonded to terra cotta units. This redundancy is especially recommended where repairs are made in areas not readily accessible for regular inspection or in high areas above public thoroughfares where an adhesion failure could result in a dangerous fall of heavy fragments that could cause severe injury or loss of life.

There has been insufficient time for proper evaluation of the long-term performance of the aforementioned conservation systems under real-life conditions. If aesthetic concerns are an issue, replacement of the unit should be considered. Again, accurate documentation of conditions and treatment will help build an information base, specific for this building, that will serve as an invaluable resource for determining the effectiveness of various repair practices.

Replacement with New Units. When terra cotta units are shattered or otherwise severely damaged to the point that material and structural integrity in the wall is lost, they need to be replaced. Such cases frequently occur where embedded steelwork has corroded and expanded, thereby putting excessive stresses on the terra cotta causing it to burst.

Removing and re-anchoring damaged glazed terra cotta is an extremely difficult if not impossible task. The complexity of the interlocking system of masonry units, backfill, and metal anchoring system precludes the removal of the terra cotta unit without destroying it. Reanchoring deteriorated units is likewise impossible. Therefore, if the terra cotta unit in question is loose, severely deteriorated, or its structural integrity is a serious question, it is best to remove and replace the unit. Partial in situ repair will not be as long lasting and may cause complicated restoration problems later on.

The best solution is replacement with new terra cotta units designed to match the original in terms of overall dimensions, surface detail, texture, color, and physical characteristics such as compressive strength, absorption and thermal expansion co-efficient.

In kind replacement is possible but is will never be a perfect match. Most new terra cotta is machine made, not hand made as the original. The porous body of the new material tends to be more uniform but is less dense and often not as durable. The glaze on new terra cotta tends to be thinner and subsequently more brittle than the older material. Machine production also creates a glaze that is more uniform in color as opposed to richer historic glazes. Ornate pieces must be still be hand cast, a rather expensive and time-consuming process, and their execution should be planned far in advance.

There is a limited range of potential substitute materials that have been used with varying degrees of success: precast concrete, stone, artificial or cast stone, glass fiber reinforced polyester resin on a steel support frame, and cast aluminum. All have their own peculiar maintenance and durability issues and none will compliment the historic look of the original terra cotta the way replacement in kind will. Structural and visual compatibility are always major considerations when choosing replacement materials.

- Stone, although visually compatible, is heavier and may be more costly especially where rich detailing must be carved to match the original. On the other hand, metal anchoring is easily accommodated and producing simple shapes, along the base course for example, may actually be more cost effective.

- Fiberglass replacement may be a viable alternative when rich and elaborate ornamentation has to be duplicated. Castings from original intact pieces can produce numerous copies of moldings, balusters, voussoirs, etc. Pieces are relatively lightweight and anchoring can easily be incorporated into in the casting. The significant drawbacks are color compatibility, fire code violations, poor weathering and aging properties due to susceptibility to ultra violet light.

- Pre-cast units, like fiberglass, are able to replicate nuances in detail in modular fashion; they can be hollow cast, use lightweight aggregates and be made to accommodate metal anchoring. Concrete and cast stone can be tinted to match the existing materials with better results than achieved with resins and the materials are much more durable. It is cost effective and once production is in process, precast materials can be produced quickly and easily. Visual compatibility of the new unit is achieved through masonry coatings that control moisture absorption, obtain proper reflectivity in imitation of the original glaze, and prevent weathering of the unit itself.

Temporary replacement measures should be implemented when missing units are scheduled for replacement but work cannot be immediately performed due to lengthy delivery time, prorating of work, or seasonal considerations. Severe deterioration should be protected against further damage until appropriate repair or replacement can begin.

Temporary repointing, removal and saving of undamaged units to be reset later, or the temporary installation of brick infill to keep deterioration in check might be considered.

Alteration Repair. Holes, sign anchors, slots for channel steel, abandoned steel supports, or structural cracking in the surface of terra cotta units should be sealed with a material that will expand with the normal dynamics of the surrounding material, yet effectively keep water out of the system. Special attention should be paid to whether cracks are static or moving and sealants should be chosen accordingly. It is important to remember that waterproof caulking compounds are not viable repointing materials and should not be used as such.

Repointing. Repointing mortar joints that are severely deteriorated or improperly or infrequently maintained is one of the most useful conservation efforts that can be executed on historic terra cotta buildings. On-going and cyclical repointing guarantees the long life of the material and ultimately the building itself.

Where pointing mortars need to be replaced, the compressive strength of the terra cotta units must first be established so that the mortar mix can be made slightly weaker. Where original formulations are not available, laboratory testing and analysis can help determine the physical and chemical properties of terra cotta. No matter what the original mortar mixes were for bedding, setting, pointing, or backing, it must be clear that mixes for repairs and restoration work must allow for the changed state of the old terra cotta which is quite possibly no longer compatible with the original mortar mixes.

4. BUDGETING AND SCHEDULING

Repointing is both expensive and time consuming due to the extent of handwork and special materials required. "It is preferable to repoint only those areas that require work rather than an entire wall. But, if 25-50 per cent or more of a wall needs to be repointed, repointing the entire wall may be more cost effective than spot repointing. Total repointing may also be more sensible when access is difficult, requiring the erection of expensive scaffolding (unless the majority of the mortar is sound and unlikely to require replacement in the foreseeable future." (PB-2)

Seasonal aspects must be a primary consideration when scheduling the work to be done. Generally speaking, wall temperatures between 40 and 95 degrees F will prevent freezing and excessive evaporation of the water in the mortar. Ideally, repointing should be done in shade, away from strong sunlight in order to slow the drying process, especially during periods of hot weather.

The relationship of repointing to other work proposed on the building must also be recognized. Ideally, scheduling should be done so that all work can take advantage of erected scaffolding. In some cases, it may be more cost effective to perform additional minor repairs, repairs that, under normal circumstances, could be delayed, while the scaffolding is in place.

Building managers must recognize the difficulties that a repointing project can create and work should be coordinated to avoid potential conflicts. The repointing process is time consuming and scaffolding will need to remain in place for an extended period of time. This will interrupt the normal operation of the building both physically and visually. Joint preparation is noisy and generates large quantities of dust, which must be controlled, especially at air intakes or where it might damage operating mechanical equipment or machinery.

5. EXECUTION OF THE WORK

Selecting a Contractor: In a competitive bidding situation, it is important to ensure that the specifications require that masons must have a minimum of five years experience with repointing historic buildings to be eligible to bid the project. Requiring proof of qualification ahead of time will simplify the bidding process by eliminating unqualified bidders ahead of time.

Contract Documents: Contract documents should call for unit prices as well as a base bid. Unit pricing forces the contractor to determine in advance what the cost of addition or reduction will be for work that varies from the scope of the base bid. Each type of work to be performed- brick repointing, terra cotta repair, masonry replacement, etc., should have its own unit price. If, for example, the contractor has ten fewer terra cotta units to replace than indicated on the contract documents but eighty more feet of brick repointing, it will be relatively easy to determine the final price for the work. The unit price should also reflect quantities; one linear foot of pointing in five different spots will be more expensive than five contiguous lineal feet.